REPORT NO. CG-D-75-77

COST EFFECTIVENESS STUDY OF WASTEWATER MANAGEMENT SYSTEMS FOR SELECTED U.S. COAST GUARD VESSELS

Volume III - Installation Analysis

Part 2 - VIGOROUS (210')

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February 1977

FINAL REPORT

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
OFFICE OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20590

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15. Supplementary Notes

Volume III of a six volume report. Volume III has been published in six parts.

16. Abstract

Each of the 18 candidate Wastewater Management System (WMS) configurations developed in Volume IV was analyzed for installation aboard the VIGOROUS (WHEC - 627). The following information was developed: vessel conditions including locations of black water (sewage and garbage grinder slurry) and gray water (galley and turbid) waste sources, vessel/resources capacities and estimated usage rates, determination of viable candidate systems based on installation guidelines and assumptions developed in Volume IV, black and gray wastewater (or sludge) holding tank capacities which can be fitted, installation cost estimates for each viable candidate system, arrangement drawings for WMS equipment and waste sources, installation related effectiveness attribute data.

The analysis was performed in three stages. A preliminary installation analysis was made on the basis of vessel plans available. This was followed by a shipcheck of the vessel to determine the viable candidate systems and obtain required vessel data. The final step consisted of a more detailed analysis of each viable candidate system to develop installation cost estimates and other required installation related information including arrangement drawings and effectiveness attribute data. Cost estimates were developed using a form which analyzes each viable candidate system in terms of standard installation cost elements, each of which has an assumed unit cost.

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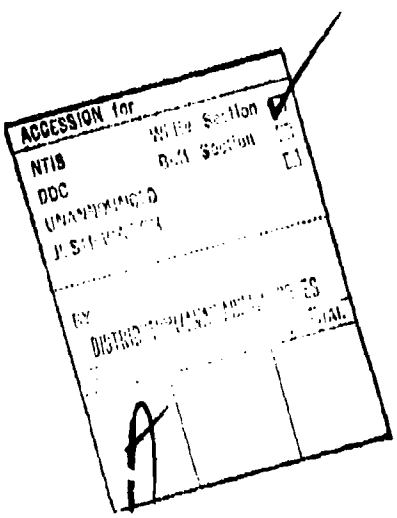
This study was conducted under the technical direction of Mr. Thomas S. Scarano of the Office of Research and Development, U.S. Coast Guard. Mr. Scarano and Lt. Ed Magsig of the Office of Engineering made available the vessel plans and provided valuable assistance in the formulation of the guidelines and assumptions governing this installation analysis.

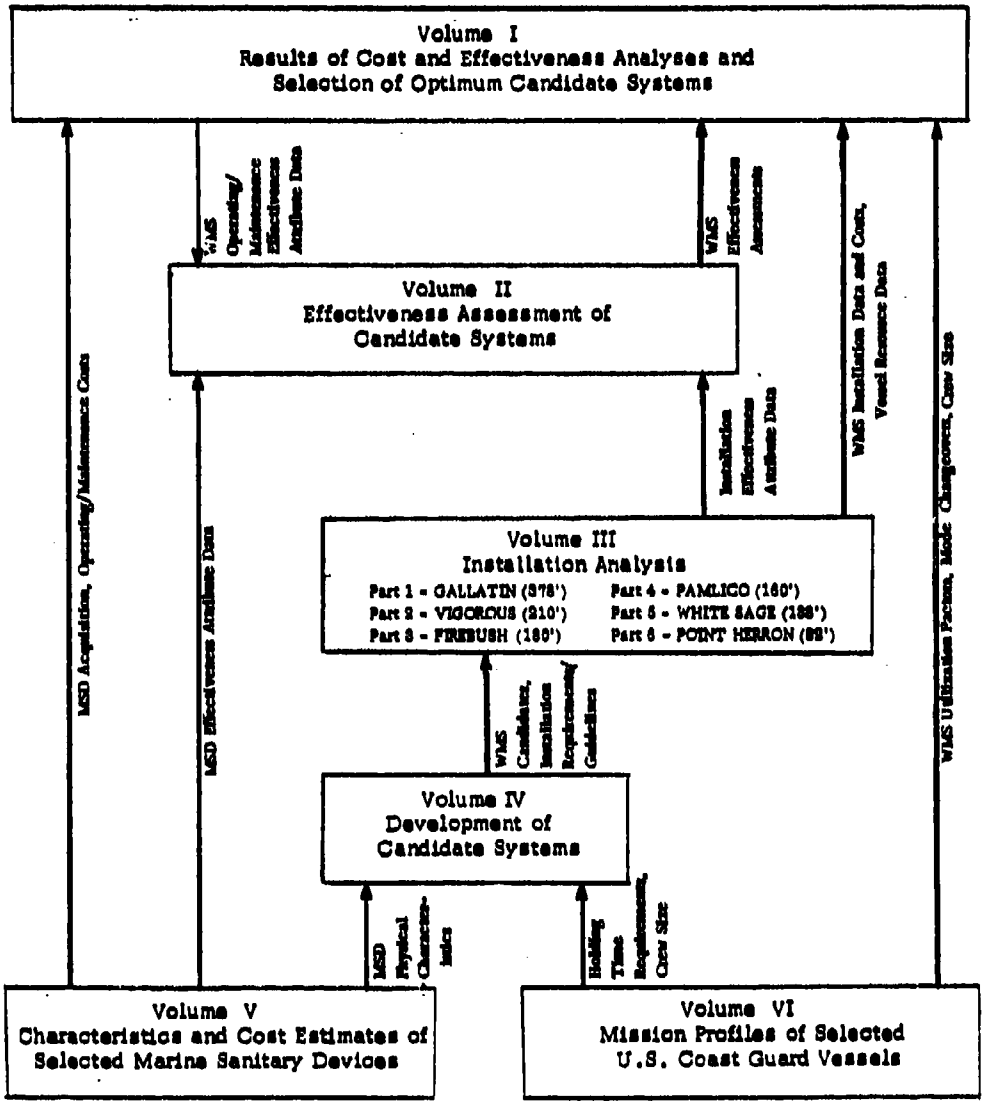
The installation analysis was performed in consultation with George G. Sharp, Inc., 100 Church Street, New York, N.Y. 10007.

The cooperation and assistance of the officers of U.S. Coast Guard Cutter VIGOROUS (WHEC-627) in scheduling the shipcheck and providing the requested vessel data is greatly appreciated.



PREFACE

The relationship among the volumes of the report is depicted below. This relationship does not convey all the information contained within each volume.



SUMMARY OF WMS INSTALLATION COSTS

Vessel: VIGOROUS (210')

WMS No.	TYPE: Coll/Trans Subsys (Black)	TYPE: Treatment/Disposal Subsystem: Black	TYPE: Treatment/Disposal Subsystem: Gray	Holding Capacity: Black (%)	Holding Capacity: Gray (%)	INSTALLATION COST ($)
1	Gravity Collect.	Holding Tank	Holding Tank	40	1	10,200
2	Oil Recircul. (Chrysler)	Chrysler + Hld Tnk	Holding Tank	53	1	13,230
3		Chrysler + Incin.	Holding Tank	N/A		
4	Gravity Collect. (Grumman)	Grum Flow Thru+HldTk	Holding Tank	N/A		
5		Grumman Flow Thru + Holding Tank		N/A		
6	Gravity Collect.	Holding Tank	Grum Flow Thru+HldTnk	N/A		
7	Gravity Collect. (Grumman)	Grum Flow Thru+Incin.	Holding Tank	N/A		
8		Grumman Flow Thru + Incinerator		N/A		
9	Vacuum Collect. (Jered)	Holding Tank	Holding Tank	48	1	16,270
10		Incinerator	Holding Tank	100	1	23,530
11		GATX Evap.	Holding Tank	N/A		
12		Holding Tank	Grum Flow Thru+ Hld Tnk	N/A		
13		Incinerator	Grum Flow Thru + Incin.	N/A		
14	M/T Pump Collect. (GATX)	Holding Tank	Holding Tank	100	1	13,650
15		Incinerator	Holding Tank	100	3	20,890
16		GATX Evap.	Holding Tank	100	1	11,560
17		Holding Tank	Grum Flow Thru+Hld Tnk	N/A		
18		Incinerator	Grum Flow Thru + Incin.	N/A		

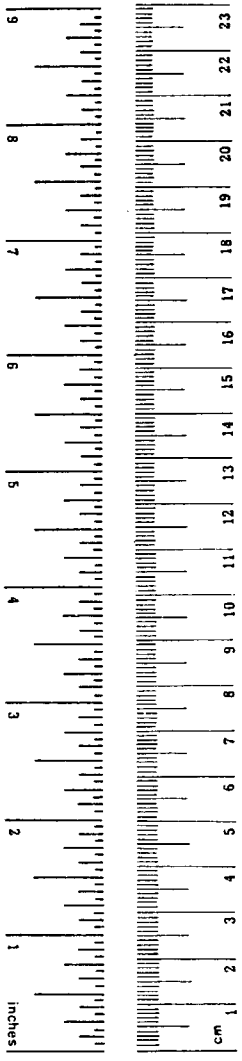
N/A - Not a viable candidate system for this vessel.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

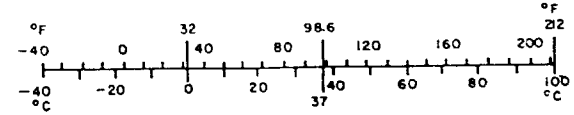
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

OBJECTIVES

The objectives of the installation analysis are as follows:

- Development of pertinent vessel information necessary for the cost and effectiveness analyses, including the following:
  - Existing physical conditions aboard the vessel, especially in compartments where wastewater management system equipments may be installed.
  - Existing wastewater management equipments/systems aboard the vessel (holding tanks, garbage grinders, sewage treatment systems, etc.).
  - Location of black and gray wastewater sources aboard the vessel.
  - Vessel resource capacities and estimated usage rates (prior to system installation).
- Selection of the viable candidate systems as determined on the basis of the feasibility of installation, using the governing installation guidelines and assumptions.
- Determination of the black/gray wastewater (or sludge) holding tank capacities which can be fitted.
- Development of installation cost estimates for each viable candidate system.
- Development of drawings showing the proposed arrangement of the wastewater management system equipments for each viable candidate as well as the arrangement of the black and gray wastewater sources on board the vessel.
- Development of installation related effectiveness attribute data.

ASSUMPTIONS

The pertinent assumptions and guidelines governing the installation analysis are presented in Volume IV of this report, along with the details of each of the 18 candidate wastewater management system concepts in configurations suitable for each vessel included in this study.

APPROACH

The installation analysis was performed in three stages consisting of a preliminary installation analysis, a shipcheck to establish viable system/vessel combinations, and an installation cost analysis all of which are discussed below. Prior to this analysis, visits were made to a number of vessels to inspect installations of the wastewater management subsystems and equipments included in this study.

Preliminary Installation Analysis

The candidate ship's general arrangement drawings and piping diagrams as furnished by the U.S. Coast Guard were reviewed at length to determine existing conditions so that the WMS requirements delineated in Volume IV could be applied to the vessel and a preliminary installation analysis made prior to an actual visit to the ship. This approach was intended to maximize familiarity with the vessel and to determine any possible questionable areas of interest. Each system was investigated as to space requirements, possible equipment locations, relationship to ship's functions (operation, mission, fuel stowage, water capacity, support systems, etc.) and its relationship to the reportedly existing waste disposal system.

In order to obtain as accurate a picture as possible, arrangement drawings to scale were made from the ship's plans of the possible installation spaces and "dummy cut-outs" of WMS equipment (also to scale) were used to determine if a proposed arrangement was feasible and if any problems could be anticipated. The results of the preliminary installation analysis are presented in Appendix A.

Shipchecks To Determine Viable Candidate Systems

Upon completion of the preliminary installation analysis, a detailed shipcheck of the vessel was made. During this visit various factors bearing on the investigation were considered, e.g., support systems (compressed air, sanitary flushing medium, electrical power generation, salt water systems, fresh water systems, fuel oil systems, etc.), correlation between actual ship arrangement and that shown in ship's drawings furnished for the study, relationship of other ship's systems and equipment to the location

and installation of WMS components to determine interferences and relocations, access for shipping WMS equipment aboard, removals, relocations, etc. The drawings prepared during the preliminary installation study were checked out and modified to reflect actual shipboard conditions.

The discussion of the shipcheck results presents a verbal picture of what conditions actually exist aboard the vessel and how these conditions affect the viability determination of each wastewater management system. The installation acceptance or rejection rationale for each candidate WMS is presented, complete with estimated tank sizes, equipment locations, possible space modifications, relocations, limitations, exclusions, and any other such considerations as may be necessary to obtain a lucid understanding of the situation.

Vessel resource capacities (including the source of fresh water) and estimates of usage rates (prior to WMS installation) were obtained from interviews with cognizant officers. The locations of all black water (sewage and garbage grinder slurry) and gray water (galley and turbid) waste sources were determined.

The shipcheck also provided the necessary information to determine the capacities (in gallons) of required black and gray wastewater (or sludge) holding tanks (not part of manufacturer supplied wastewater treatment equipment) which can be accommodated, as well as their configurations (heights). This information was used to determine the black and gray wastewater holding capacities of each viable candidate system (expressed as a percentage of the required holding time). These results are presented on the WMS Equipment Requirements form together with the other equipment types and quantities required in order to synthesize each viable candidate system on the vessel. This WMS Equipment Requirements form served as the starting point for the cost and effectiveness assessments of each viable candidate system.

Installation Cost Analysis

The following were generated as part of the installation cost analysis:

- WMS equipment arrangement drawings for each viable candidate system and arrangement drawings for the black and gray wastewater sources aboard the vessel.
- Installation related effectiveness attribute data.
- Installation cost estimates for each viable candidate system.

The starting point for the installation cost estimates was the condition of the vessel at the time of the shipcheck inspection. Each viable candidate system installation was then analyzed in terms of a fixed set of installation cost elements. The Installation Cost Estimate Form shown in Figure 1 was used to record the estimated requirements for each cost element and the associated cost was computed. Each installation cost element in Figure 1 is discussed below.

(a) Piping - Wherever possible and applicable, existing piping runs were retained for reuse as installed. Pertinent information contained in the available ship's piping plans was used insofar as practicable. New piping runs were estimated from these drawings and the system equipment arrangement drawing prepared.

For estimating purposes of this nature, it is usual marine practice to use a dollars per pound of material to be installed. Therefore, an estimated present-day price, including material and labor to install, was placed at $4.50/lb.

For the sake of uniformity and simplification since the WMS evaluations are comparative, the piping material used is copper-nickel. It is recognized that most waste disposal piping systems under consideration in the U.S. Coast Guard vessels are of copper-nickel, although some PVC (plastic) piping and a small amount of steel is used. Since the established guidelines call for the principal piping (drainage) to be of copper-nickel it was considered that for the relatively small additional piping, such as vents, the use of copper-nickel for all piping components would not adversely influence the overall results. Accordingly, the amounts of each size piping were estimated and a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.

(b) Steel - For this part of the cost estimate only the steel involved in the various shipyard supplied tanks is considered. Foundations are a separately treated item. For these tanks it was considered that one-quarter inch plate would be a good average thickness. Since the tanks would have to be structurally stiffened for proper support, a factor of 30% was added to the plate weight. The weight estimate was derived from the system guideline size requirements translated into configurations as shown on the equipment location and arrangement drawings.

For cost estimating of this nature, it is usual to apply a cost per pound figure. It was considered that a good current price of $0.55/lb. would cover material and labor for fabrication and placing on board. This does not include the cost of fixing the tanks permanently in place by welding. This is a separate consideration.

WMS INSTALLATION COST ESTIMATES

Vessel_____

WMS No._____

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	[2]	
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	[4]	
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	[5]	
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)		
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)		
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)		
Welding		Feet	$ 6.00/Ft. (Materials and Labor)		
Removals	Cutting	Hours	$50.00/Hr. [6] (Labor)		
	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)		
Total Installation Cost ($)					

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft./hr.

Figure 1

INSTALLATION COST ESTIMATE FORM

(c) Foundations - Supporting steel structure for all components of each WMS (tanks, pumps, MSD, incinerators, etc.) was estimated as approximately 10% of the weight which has to be carried. This is a usual rule of thumb for this type of installation. Fabrication and installation costs for material and labor were taken as $0.92/lb. based on consideration of today's average costs. The weights were estimated from the tank configurations and contents as well as the component weights given in Volume IV.

(d) Electrical Power Cable - The amount of footage was estimated from the ship's arrangement plans and the WMS equipment arrangement drawings prepared, with allowances for the devious routings which could be encountered. Since ship alteration work is usually more complex than new construction, allowance as made for less installation per unit time. Therefore a cost of approximately $2.00/ft. of cable was used to cover material and labor.

(e) Miscellaneous Installations - To cover the installation of various items such as pumps, motors, skid-mounted components, etc. where the activity centers principally around alignments and bolting in place, an estimate was made of the amount of time it would take to perform the tasks for each system installation, since the number and type of components varies. An estimated shipyard labor cost of approximately $15 per man-hour (MH) was considered representative.

(f) Access Cuts - In order to get material and components into the compartments where they would be fitted it could become necessary to temporarily cut the ship's hull, or deck plating or a bulkhead to provide passageway. The number of feet of cutting was estimated for each system installation based on the approximate size of the largest component anticipated. Estimated shipyard cost for such cutting is approximately $1.00/ft.

(g) Welding - This consideration includes securing tanks and non-bolted items and welding back any plating temporarily cut to provide access. An estimate of the number of feet of welding was made for each item in each system and a cost factor of $6.00/ft was considered satisfactory to cover material and labor.

(h) Removals - In cases where some existing equipment would have to be cut and removed from the vessel as no longer required, an estimate was made as to the approximate length of time it would take a team of two men to accomplish certain tasks. Estimated factors of $50/hour for cutting (based on an estimated cutting rate of 50 ft/hour) and $15/man-hour (MH) for miscellaneous handling labor were considered representative of such costs.

(i) Other Considerations - The installation cost estimates do not include some shipyard costs which yards to include as a matter of quotation to perform a certain ship modification. Such intangibles would include: cleaning and gas-freeing tanks, temporary removals or modifications to ducts, piping, electric cables, machinery, ship's outfit or furnishings, etc. and re-installation to existing state after the basic modification has been completed; cleaning, preparing and repainting the compartments and parts of the steel work distrubed, use of special rigging and shipyard lifting gear; and other work items which are part of a hipyard's everyday business and which are normal for them to price out.

If a complete ship alteration price is desired, it would involve drawing up a complete set of specification and drawings in sufficient detail for a shipyard's estimating department to analyze at length. If possible, yard personnel would prefer to visit the vessel for a more accurate cost estimate to eliminate or minimize costs which it could possibly have to absorb.

One of the most difficult factors to consider and which is not obvious but which is very much a determinant is the shipyard's workload or backlog. If there is a convenient "hole" in the yard's work schedule, the price could be made attractive since it would provide needed economic continuity for its work force and facilities. Certainly if there is little or no other work in the offing, the yard will be inclined to "buy" the job by bidding lower than it normally would.

Thus it can be seen that there will be additional costs to those detailed herein, if one is interested in a "finished product" price than a comparative estimate.

LIMITATIONS

The installation cost estimating procedures used are considered to be fairly general and applicable for study purposes of this type which places greater emphasis on relative cost among candidate systems rather than on the absolute cost for a given system. However, the installation cost estimates developed herein are based on specific vessel conditions, wastewater management system requirements and the governing installation guidelines and assumptions. Therefore, caution is advised in attempting to use these estimates directly for vessels and/or systems other than those specifically included in this study.

PERTINENT VESSEL INFORMATION

VIGOROUS (210')

Vessel Characteristic	Data
Class	WHEC - 627 Resolute (210') B Class
Type	Medium Endurance Cutter
Crew Size	60
Home Port	New London, Connecticut

SHIPCHECK OBSERVATIONS OF EXISTING VESSEL CONDITIONS

VIGOROUS (210')

Crew 60 Men

Waste Sources

Complete information on the sewage and gray water waste sources is contained in the tabulation sheets forming a part of these introductory remarks.

Existing Arrangement

The vessel is fitted with a salt water sanitary flushing system via two (2) pumps (but no hydropneumatic tank).

The fresh water system is served by two (2) pumps with a hydropneumatic tank.

Compressed air is furnished via three (3) separate systems with their own tanks (ship's service, diesel starting, and control air).

As fuel is consumed, the tanks when emptied are then filled with sea water ballast as required. There are no other means for ballasting or weight compensation.

The vessel is fitted with separate drainage systems, one for sewage and one for galley and turbid. The system drains from the various spaces are combined with similar drains from other spaces where possible, forming small mains which, in turn, combine and eventually enter the Sewage Treatment Space (3-84-0-Q) on the Third Deck. This space contains a Galley and Turbid tank of approximately 100 gallons capacity and a Sewage Tank of approximately 680 gallons.

The sewage mains enter the sewage tank and the galley/turbid mains enter the galley and turbid tank but a valved crossover permits gray water to be routed to the sewage tank if necessary. There is no gravitational system overboard. Drains collected in these tanks are pumped overboard and to pierside via special connections in the weather, port and starboard.

Special Remarks

There appear to be some spaces which are otherwise utilized at present but which are identified for future assignments (armament, navigation, etc.) necessary for the vessel's operation profile. These are not considered available for purposes of this investigation. There were no other spaces found suitable for any parts of the various system installations.

There is no ship's stack, since engine exhausts are routed aft through the stern. Therefore, running incinerator stacks will require particular investigation. The solutions are not immediately apparent and would require additional study and approval before the specific waste management systems involved would be considered viable unconditionally. Illustrative of the complexity of a possible consideration is to run the stack into the IC & Gyro Room, up through the linen locker and closet on the next deck, then up through one end of the Ward Room on the Main Deck, up through a corner of a Stateroom on the 01 Deck, up through the Naval Stores Closet on the 02 Deck and up to the weather on the Bridge Deck to port of the mast. The run would have to be well insulated and sheathed wherever it passes through a space.

VESSEL RESOURCES

Vessel; VIGOROUS (WHEC - 627) - Resolute (210') B Class

1. Fresh Water
   a. Source of supply (i.e., storage tank, evaporator) In Port - Use shore facility to storage tanks
      Evaporator - 2,500 gals per day - Underway
   b. Capacity (# of gals, etc.) (2) (1) Forward Tank - 4,100 gals
      Aft. Tank - 3,600 gals
   c. Usage rate (# of gpd, etc.) 2,000 gpd

2. Fuel Oil
   a. Tank capacity (# of gals) (6) Storage Tanks - (2) Service Tanks - (1) (4-84-2F) -6,000gals; (1)(4-143-1-F) - 6,000 gals; (1)(4-72-2-F) - 6,000gals; (1)(4-90-1F) -6,000 gals; (1)(4-143-2F) -6,000 gals; (1)(4-84-1F) - 6,000 gals; (1)(4-96-2F) - 6,000 gals.
   b. Usage rate (gpd, etc.) In Port - Winter - 20 gpd
      Underway - 1,800 gpd

3. Electric Power
   a. Capacity kw (2) Diesel Generator - 200 kw wach. (1) Emerg. Gen. Diesel - 100 kw
   b. Usage rate (when) In Port - Use Shore Facility - 150-200 amp.
      Underway - 150 kw.
   c. Maximum kw used 312 kw.
   d. Average kwh per day 3,600 kw

4. Compressed Air
   a. Capacity (1) Ships Service - 125 psi (2) Starting Air Comp. - 250 psi each (1) Control - 100 psi
   b. Usage rate Use for ships service, maintenance; starting Eng.
   c. No. of hours compressors run per day or percentage of time During Maintenance - 90% Starting Air - Use for starting engines
      Otherwise - 25-30%

5. Capacity of Ventilation Air in CFM
   Location; Type; CFM: (3-102-1) Forward Mach. Rm (2)(Supply) - 750 CFM each; (3-102-2) Forward Mach. Rm (Exhaust) - 1,500 CFM; (2-121-2) Eng. Rm (Exhaust) - 5,500 CFM; (2-132-1) Eng. Rm (Exhaust) - 5,500 CFM; (2-162-2) Comm. Stores (Supply) 1,800 CFM; (2-164-1) Dry Stores (Exhaust) - 1,800 CFM; (2-196-2) Steer Gear Rm (Supply) - 400 CFM; (1-15-2) Bosn's Stores (Exhaust) 3235 CFM; (1-17-1) (Laundry) (Supp) - 3235 CFM; (1-116-1) Fan Rm (Supp)(2) 5,000 CFM; (1-116-3) Scullery (Exhaust) - 1,775 CFM; (1-147-1) Crews Mess (Supp) - 2,420 CFM; (01-87-4) Fan Rm (Supp) - 630 CFM; (02-87-4) (Reicrc.) - 2,400 CFM.

6. Drainage - One sewage drainage system to tank - 600 gals - (4-84-0-F)

LOCATION OF BLACK WATER* WASTE SOURCES ABOARD A VESSEL

Vessel: VIGOROUS (WHEC - 627) - Resolute (210') B Class

Bulkhead Identification Frame #/To #	Level Identification	Compartment Location	Compartment Name	Number of Water Closets	Number of Urinals	Estimate of Number of People Served	Comments
79-84	02	P	Toilet	1	0	5-6	
44-59	01	P	C.O. SRT and S	1	0	1	
55-59	01	CL	W.R. SRT and A	1	0	1	
72-87	01	CL/S	Spare W.R.T. and S	1	0	2	
52-65	1	CL/P	Crew's T and S	2	1	30	
32-52	2	CL/S	Crew's T and S	1	1	17	
52-72	2	CL/P	Crew's T and S	2	1	12	
84-88	2	S	Eng. Off SRT and S	2	0	1	
72-83	2	P	W.R. SRT and S	1	0	1	
72-89	2	S	W.R. SRT and S	1	0	1	
72-93	2	P	W.R. SRT and S	1	0	1	
96-108	2	CL/S	C.P.O. T and S	2	0	4	

* Sewage (output from commodes and urinals) and garbage grinder slurry.

LOCATION OF GRAY WATER* WASTE SOURCES ABOARD A VESSEL

Vessel: VIGOROUS (WHEC - 627) - Resolute (210') B Class

Bulhead Identification Frame #/Fore &	Level Identification	Compartment Location	Compartment Name	Waste Source	Comments
32-52	2	S	Crew's T and S	Lavatories (3)	
32-52	2	CL	Crew's T and S	Shower (1)	
52-72	2	CL/P	Crew's T and S	Lavatories (4)	
52-72	2	P	Crew's T and S	Showers (2)	
72-69	2	CL/P	W.R. T and S	Lavatories (2)	
72-93	2	P	W.R. T and S	Showers (2)	
84-88	2	S	Eng. Off. T and S	Lavatory (1)	
84-88	2	S	Eng. Off. T and S	Shower (1)	
72-83	2	P	W.R. T and S	Lavatory (1)	
72-69	2	S	W.R. T and S	Lavatory (1)	
72-83	2	P	W.R. T and S	Shower (1)	
72-89	2	S	W.R. T and S	Shower (1)	
96-108	2	P	C.P.O. T and S	Lavatories (2)	
99	2	P	Passage Way	Drinking Fountain	Drain to Turbid Collection Tank
96-106	2	P	C.P.O. T and S	Shower (1)	
156-172	2	S	Commissary Stores	Drain from Freezer Freezer	
156-172	2	P	Commissary Stores	Drain from Ice Cube Mach.	
156-172	2	P	Commissary Stores	Drain from Refrig. Locker	
84-96	3	CL	Sewage Treatment Space	Retention Tank (600 gal) Retention Tank (100 gal)	
157-172	3	P	Refrig. Mach. Space	Refrig. Drain Tank	

* Galley and turbid wastewater.

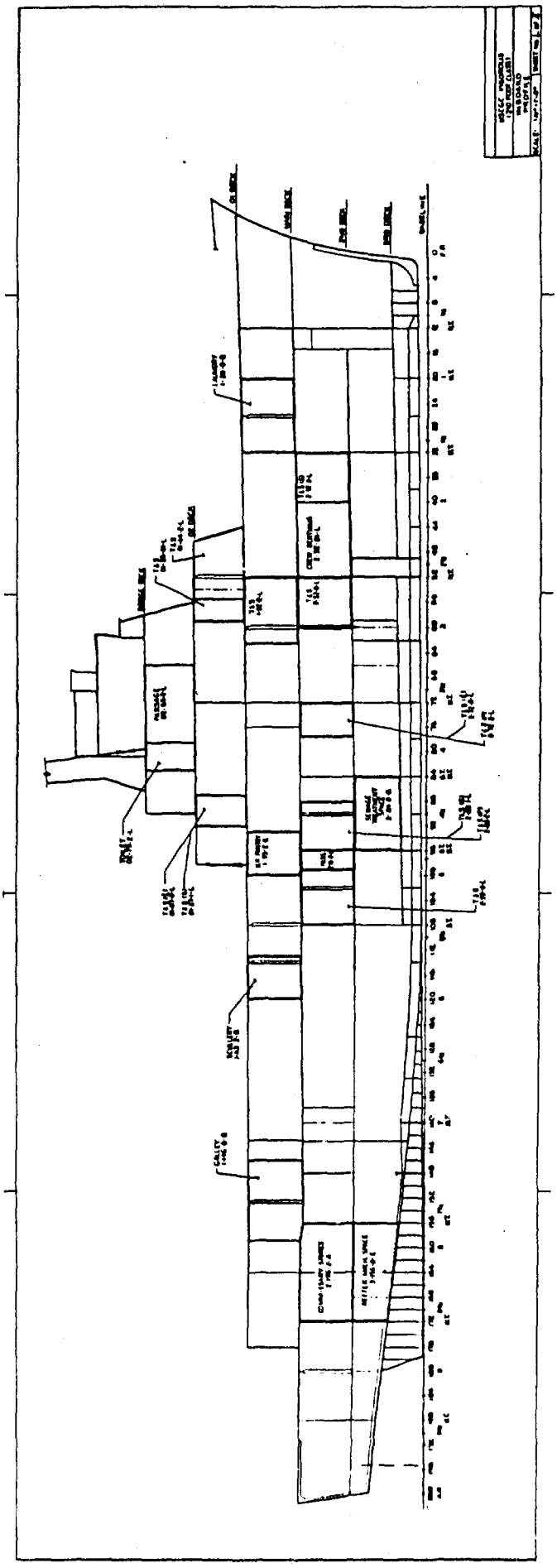
LOCATION OF GRAY WATER* WASTE SOURCES ABOARD A VESSEL

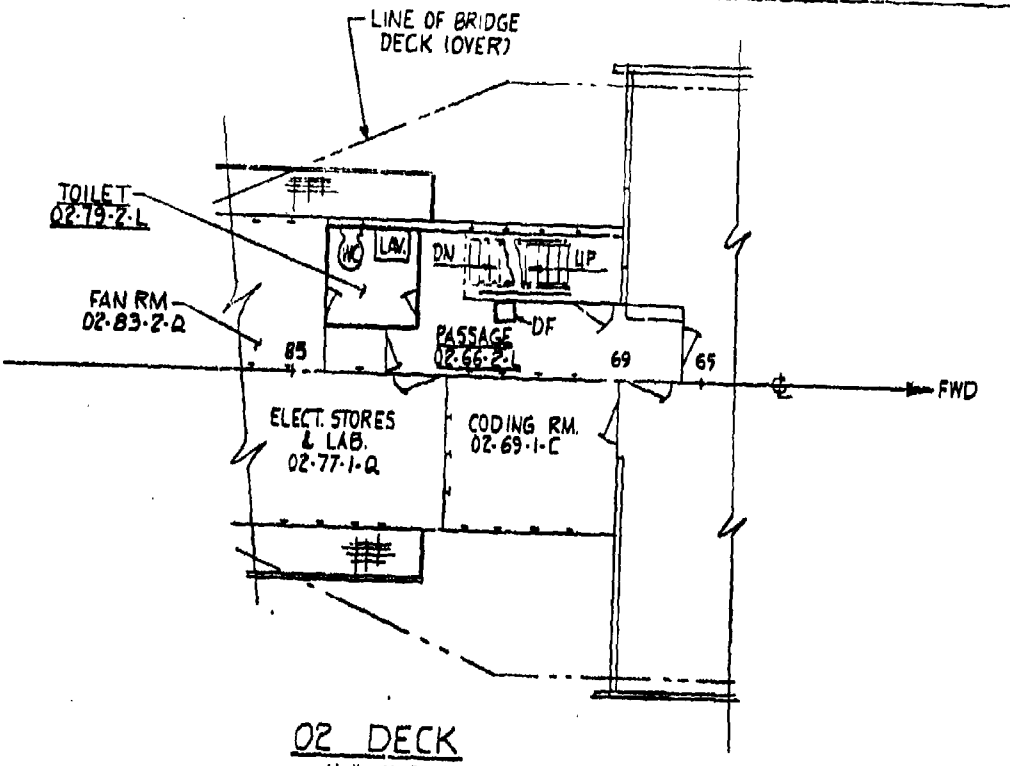
Vessel: VIGOROUS (WHEC - 627) - Rosolute (210') B Class

Bulhead Identification Frame #/To =	Level Identification	Compartment Location	Compartment Name	Waste Source	Comments
79-84	02	P	Toilet	Lavatory (1)	
76	02	P	Passage Way	Water Fountain	Drain to Turbid Collecting Tank
44-59	01	P	C.O.T. and S	Shower (1)	
44-59	01	P	C.O.T. and S	Lavatory (1)	
55-59	01	CL	W.R. SR T and S	Lavatory (1) Shower (1)	
72-87	01	CL	Exec. Off. T and S	Shower (1) Lavatory (1)	
72-87	01	S	Spare T and S	Shower (1) Lavatory (1)	
20-32	1	CL	Laundry	Washers (3)	
52-65	1	CL	Crew's T and S	Showers (2)	
52-65	1	P	Crew's T and S	Lavatories (4)	
93-100	1	P	W.R. Pantry	Sink (1)	
93-100	1	P	W.R. Pantry	Garbage Grinder	(Not operating)
113-115	1	P	Scullery	Sink (1)	
113-115	1	P	Scullery	Dishwasher (1)	
113-115	1	P	Scullery	Garbage Grinder	
146-159	1	CL	Galley	Drain from steam table	
146-159	1	CL	Galley	Drinking Fountain	Drain To Turbid Collection Tank
146-159	1	P	Galley	Sink (1)	
146-159	1	S	Galley	Kettles (2)	
146-159	1	S	Galley	Sink (1)	

* Galley and turbid wastewater.

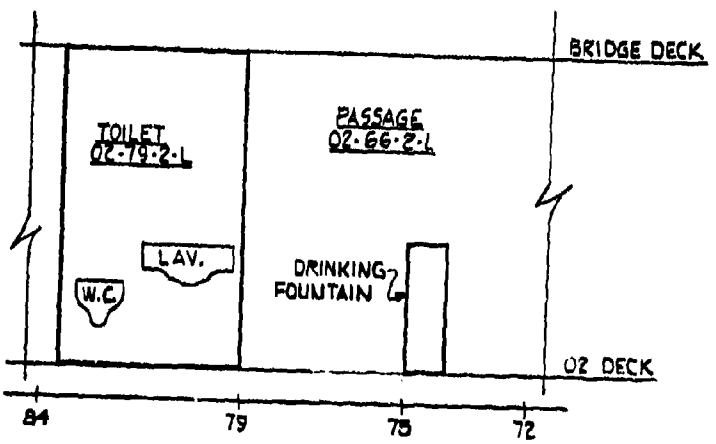
ARRANGEMENT OF BLACK AND GRAY WASTEWATER SOURCES





02 DECK

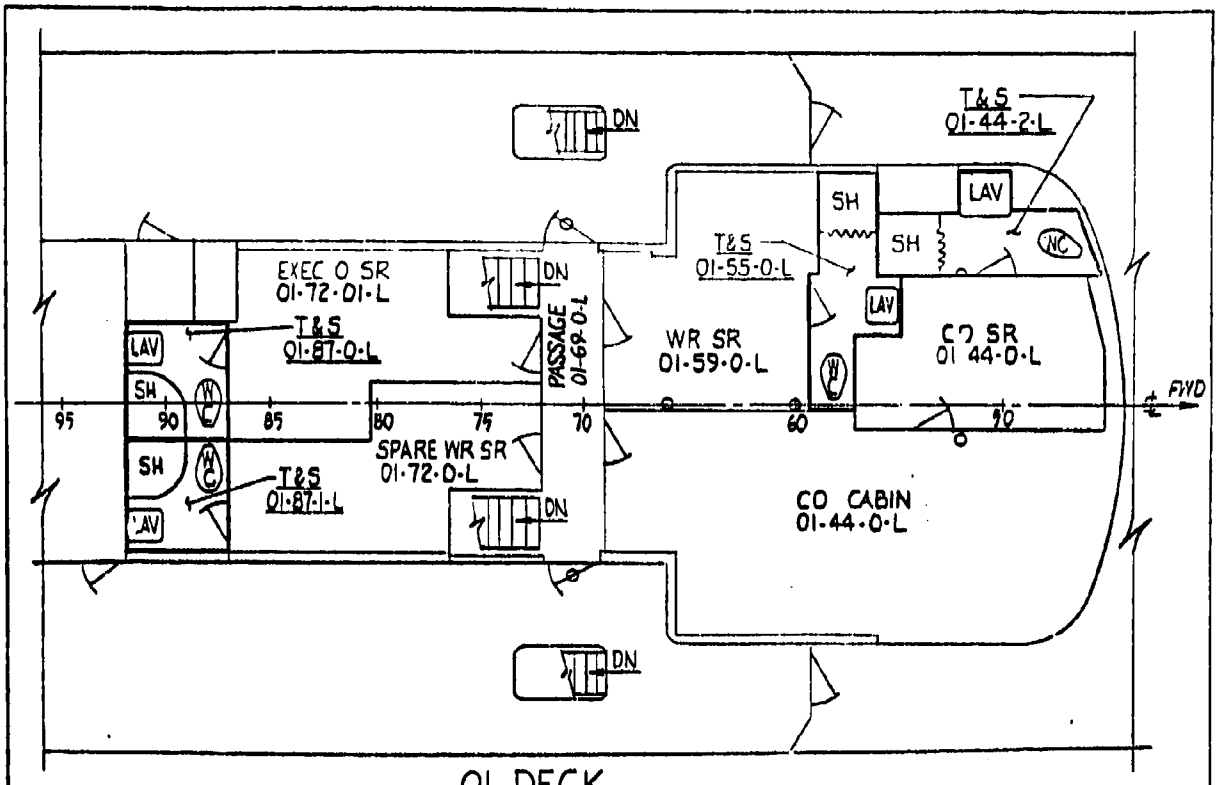
1/8" = 1'-0"



ELEVATION LOOKING TO PORT

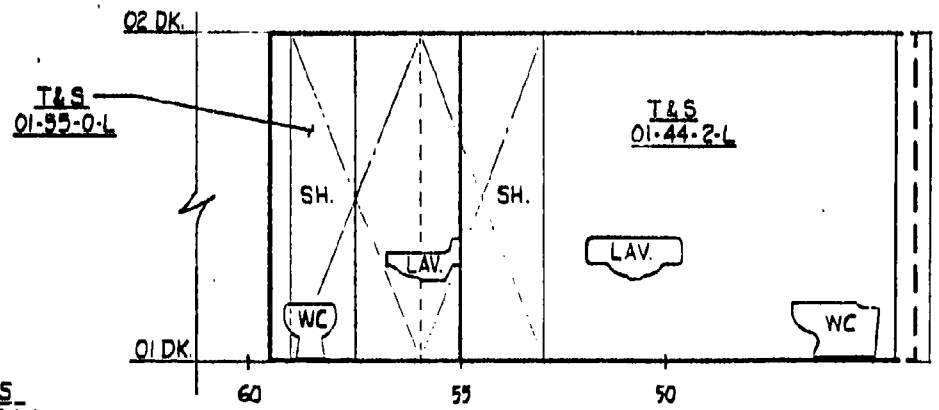
1/4" = 1'-0"

USCGC VIGOROUS (210 FOOT CLASS)
02 DECK PLAN & ELEVATION
SCALE: AS NOTED | SHEET NO. 2 OF 5



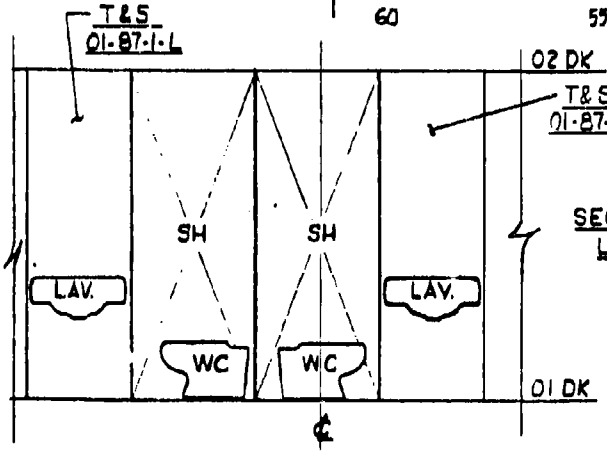
01 DECK

1/8" = 1'-0"



ELEVATION LOOKING TO PORT

1/4" = 1'-0"



SECTION AT FR 87

LOOKING AFT

1/4" = 1'-0"

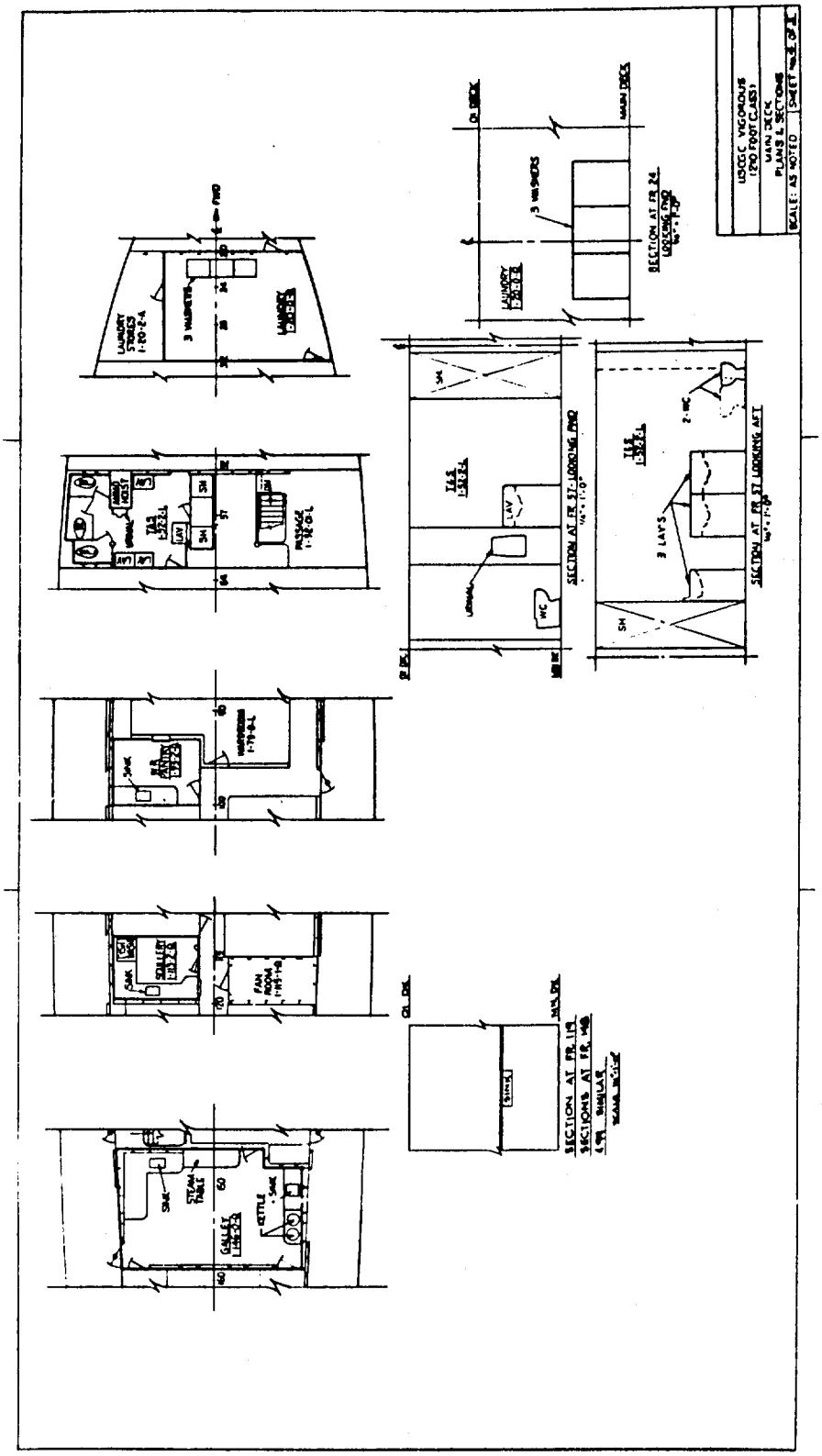
USCGC VIGOROUS

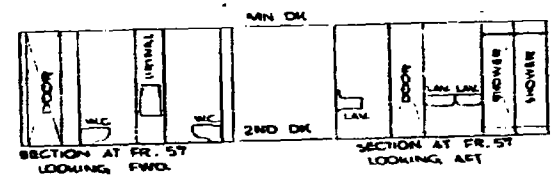
(210 FOOT CLASS)

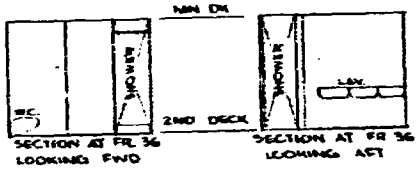
01 DECK

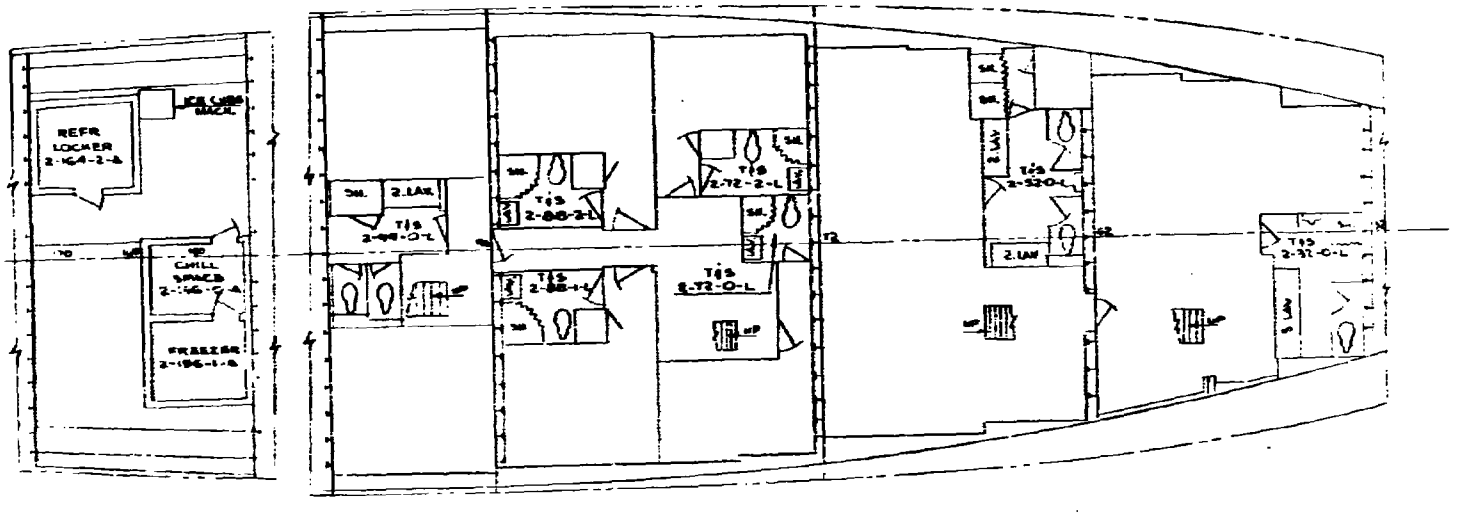
PLAN, ELEVATION & SECTION

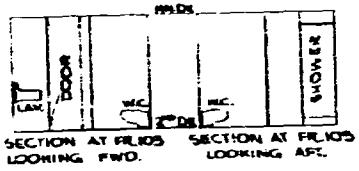
SCALE: AS NOTED | SHEET No. 3 OF 5

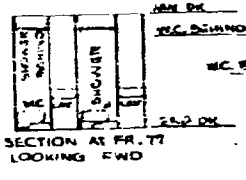


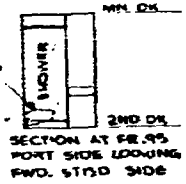












210 FT. U.S.C.G.C. VIGOROUS
SECOND DK PLAN & SECTIONS
SCALE: 1/8" = 1'-0" | SHEET NO. 5 OF 5

WMS EQUIPMENT REQUIREMENTS

Vessel VIGOROUS (210')

WMS NUMBER	WMS ACCEPTABILITY: For Installation (Yes/No)	Holding Time (%): Black	Holding Time (%): Gray	Safety (Yes/No) (1)	NUMBER OF FIXTURES: Commodes (2)	NUMBER OF FIXTURES: Urinals (3)	JERED: NUMBER OF VCT's (Sized By Gallons): Small Boat 30	Small Boat 60	Small Boat 120	Large Boat 200	Large Boat 250	JERED: NUMBER OF INCINERATORS: Jered	Thiokol	Number of M/T Pumps	GATX: NUMBER OF EVAPORATORS (Sized By Gallons): 20	40	60	80	Number of Vapor Treatment Sections	Number of Treatment Subsystems	Number of Thiokol Incinerators	GRUMMAN: COLLECTION AND RECIRCUL. SUBSYSTEM: Number of Separator Tanks: Model A	Model A/B	Model B	CHRYSLER: COLLECTION AND RECIRCUL. SUBSYSTEM: Number of P&FM Packages: Model A	Model B	CHRYSLER: INCINERATOR SUBSYSTEM: Number of Sludge Surge Tanks: Model B	Model C	Number of Incinerators: Model A	Model C	TANKS (4): BLACK (Gallons Each Tank)	TANKS (4): GRAY (Gallons Each Tank)
1	Yes	40	1	Yes	17S	3S																											2154B	120B
2	Yes	53	1	Yes	17S	3S																	1			1							538C	120B
3	No																																	
4	No																																	
5	No																																	
6	No																																	
7	No																																	
8	No																																	
9	Yes	48	1	Yes	17J	3S/5J					1																						740B	120B
10	Yes	100	1	Yes	17J	3S/5J					1	1																						120B
11	No																																	
12	No																																	
13	No																																	
14	Yes	100	1	Yes	17G	3S/3G								9																			1742B	120B
15	Yes	100	3	Yes	17G	3S/3G						1		9																				538B
16	Yes	100	1	Yes	17G	3S/3G								9			3		3															120B
17	No																																	
18	No																																	

WMS = Wastewater Management System
P&FM = Pressurization and Fluid Maintenance
(1) Does WMS meet all applicable safety standards?
(2) Letter following entered number means: S = Standard, J = JERED, G = GATX
(3) Letters following entered numbers mean: S = Standard urinal only, S/J = Standard urinals with indicated number of Jered urinal discharge valves, S/G = Standard urinals with indicated number of GATX flushometers.
(4) Letter following entered gallonage denotes tank usage: A = Influent Surge, B = Wastewater holding, C = Sludge holding, D = Intermediate tank not supplied with MSD.

WMS No.	1, 2, 9	14
Tank Height	6'-0"	5'-0"

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 1 Full Volume Flush Gravity Collection/Holding Tank for Black Water/Holding Tank for Gray Water

	Required
Sewage Holding Tank	5,418 gal. (724 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sewage Holding Tank Overboard Pump	Two (2)
G/T Holding Tank Overboard Pump	Two (2)

Discussion

The system is a viable candidate subject to certain limitations.

Equipment would be arranged in the existing Sewage Treatment Space (3-84-0-Q) on the Third Deck as follows:

(a) Due to space limitations the Sewage Holding Tank would be restricted to 2,154 gallons (288 cu. ft.). The tank would be approximately 6'L x 8'W x 6'H and would straddle the vessel's centerline at the forward end of the compartment.

(b) The galley and turbid drains cannot gravitate overboard since the vessel's waterline is just under the Second Deck level. Therefore, a minimum gray water holding tank would be fitted. The tank would be 150 gallons (20 cu. ft.), approximately 2 ft. in diameter by 6 ft. high, and located aft and to stbd of the Sewage Holding Tank.

(c) The Sewage Holding Tank Overboard Pumps and the Gray Water Holding Tank Overboard Pump would be located at the aft end of the compartment.

Vessel: VIGOROUS (210')

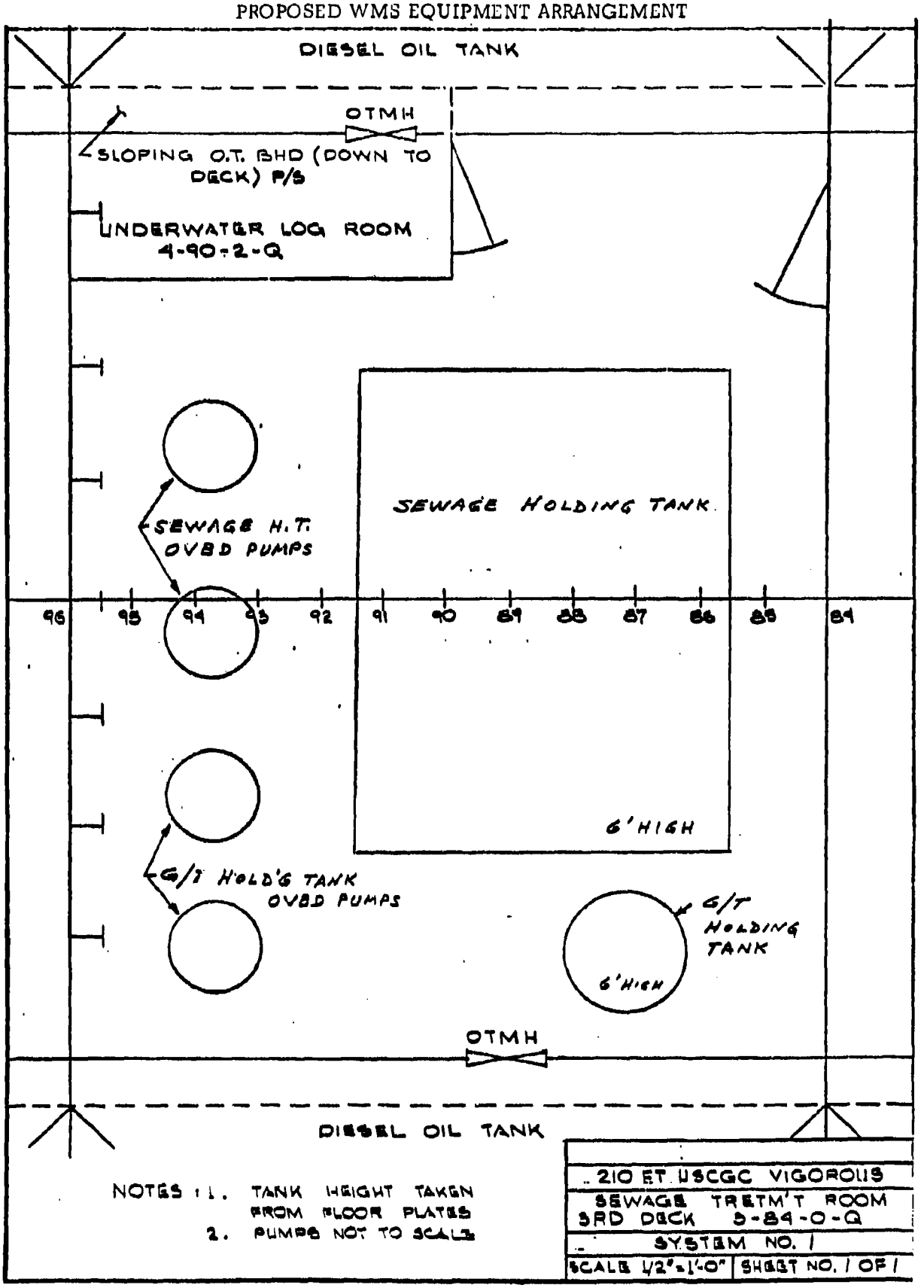
System No. 1 (cont'd.)

Drainage would be as follows:

(a) Sewage from all spaces would gravitate to the Sewage Holding Tank for discharge overboard and pierside via the tank's pumps.

(b) Galley and Turbid water would gravitate to the small gray water holding tank for discharge overboard in unrestricted waters and diverted to the Sewage Holding Tank in restricted waters and for pierside discharge.

PROPOSED WMS EQUIPMENT ARRANGEMENT



NOTES : 1. TANK HEIGHT TAKEN FROM FLOOR PLATES
2. PUMPS NOT TO SCALE

210 FT USCGC VIGOROUS
SEWAGE TRETM'T ROOM 3RD DECK 5-84-0-Q
SYSTEM NO. 1
SCALE 1/2"=1'-0" | SHEET NO. 1 OF 1

WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 1

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	500[2]	2,250
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	4,010[4]	2,206
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	2,410[5]	2,218
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)	300	600
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)	35	525
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)	55	55
Welding		Feet	$ 6.00/Ft. (Materials and Labor)	95	570
Removals	Cutting	Hours	$50.00/Hr.[6] (Labor)	25	1,250
	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)					10,199

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft./hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 2 Full Volume Flush Oil Recirculation and Gravity Collection/ Chrysler System with Sludge Holding Tank for Sewage/Holding Tank for Gray Water

	Required		
Sewage Holding Tank	1,011 gal. (135 cu. ft.)		
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)		
Chrysler Model and Quantity			
	Option A	Option B	Option C
Separation Tank	One(1) - A/B	One(1)-A & One(1)-A/B	Three(3)-A
Fluid Maintenance and Pump Package	One(1)-A	Two(2)-A	Three(3)-A
Sewage Holding Tank Overboard Pump	Two(2)		
G/T Holding Tank Overboard Pump	Two(2)		

Discussion

The system is a viable candidate subject to certain limitations.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) Due to space limitations the Sewage Holding Tank would be restricted to 538 gallons (72 cu. ft.), approximately 3'L x 4'W x 6'H, located at the forward stbd end of the compartment.

(b) The minimum gray water holding tank discussed in System No. 1 would be located in the aft stbd corner of the compartment.

(c) There is room only for Chrysler Option A. The components would be fitted along the ship's centerline, with the Separation Tank aft.

(d) The tank overboard discharge pumps would be located aft of the Sewage Holding Tank.

Vessel: VIGOROUS (210')

System No. 2 (Cont'd)

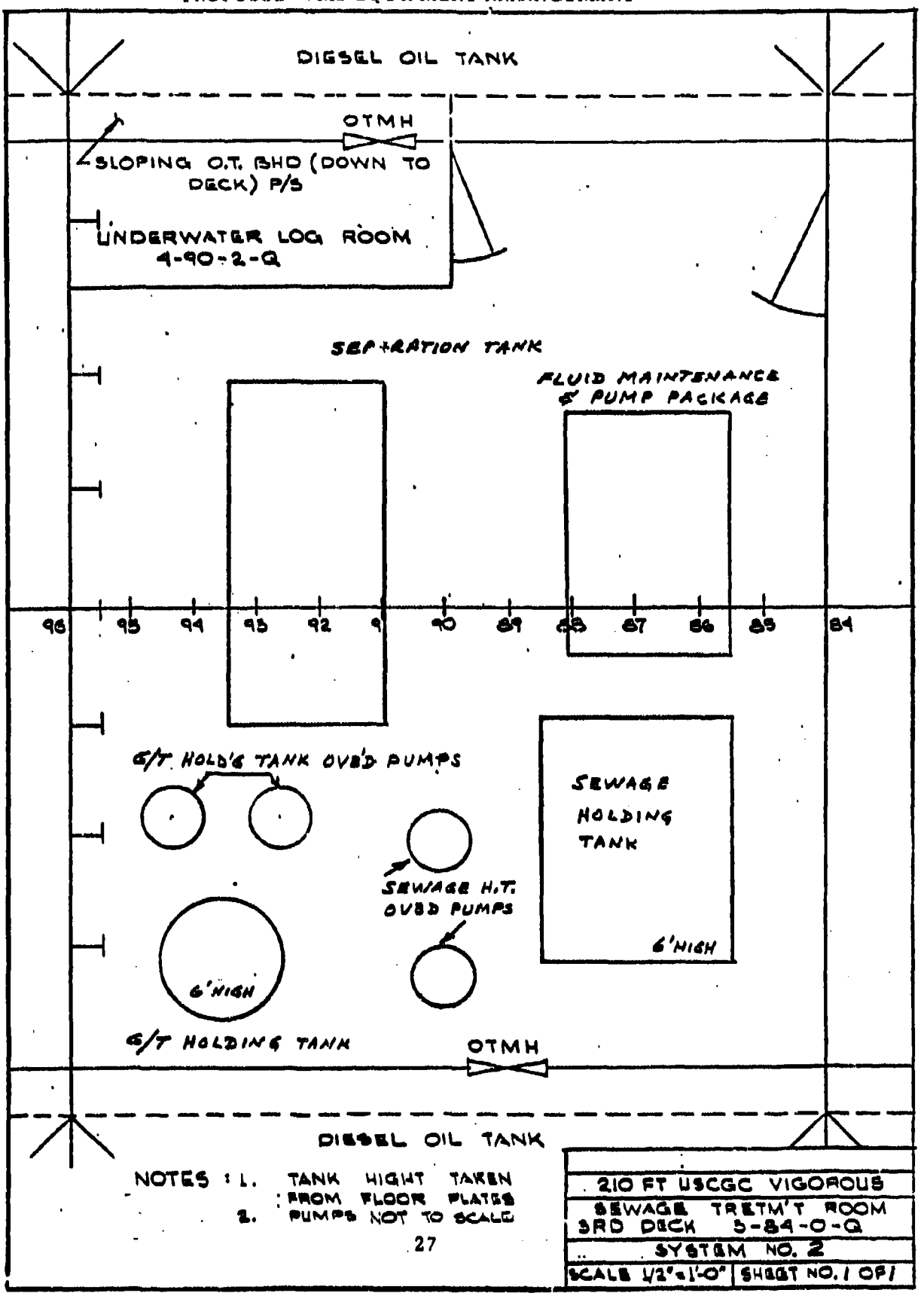
Drainage would be as follows:

(a) Sewage from all spaces except the garbage grinder would gravitate to the Chrysler Separation Tank.

(b) Garbage grinder drains would gravitate to the Sewage Holding Tank.

(c) Galley/Turbid drains would gravitate to the small gray water holding tank for discharge overboard in unrestricted waters and to the Sewage Holding Tank or pierside when overboard discharge is not permitted.

PROPOSED WMS EQUIPMENT ARRANGEMENT



NOTES : 1. TANK HIGHT TAKEN FROM FLOOR PLATES
2. PUMPS NOT TO SCALE

210 FT USCGC VIGOROUS	
SEWAGE TRETM'T ROOM 3RD DECK 3-84-0-Q	
SYSTEM NO. 2	
SCALE 1/2"=1'-0"	SHEET NO. 1 OF 1

WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 2

Installation Cost Element	Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]	Pounds	$ 4.50/Lb. (Materials and Labor)	1,705[2]	7,673
Tank Steel[3]	Pounds	$ .55/Lb. (Materials and Labor)	1,940[4]	1,067
Foundations	Pounds	$ .92/Lb. (Materials and Labor)	1,105[5]	1,017
Electric Cables	Feet	$ 2.00/Ft. (Materials and Labor)	375	750
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)	Man-Hours	$15.00/MH (Labor)	35	525
Access Cuts (in hull, deck plating or bulkhead to provide passageway)	Feet	$ 1.00/Ft. (Labor)	55	55
Welding	Feet	$ 6.00/Ft. (Materials and Labor)	60	360
Removals: Cutting	Hours	$50.00/Hr.[6] (Labor)	25	1,250
Removals: Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)				13,222

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft. /hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel. VIGOROUS (210')

WMS No. 3 Full Volume Flush Oil Recirculation and Gravity Collection/ Chrysler System with Incinerator for Sewage/Holding Tank for Gray Water

	Required		
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)		
Sludge Surge Tank	One (1) - Model B		
Incinerator Model and Quantity	One (1) - Model C		
Chrysler Model and Quantity	Option A	Option B	Option C
Separation Tank	One (1)-A/B	One (1)-A One (1)-A/B	Three (3)-A
Fluid Maintenance and Pump Package	One (1) - A	Two (2)-A	Three (3)-A
Sludge Surge Tank			
Transfer Pump	One (1)		
Overboard Pump	One (1)		
Galley/Turbid Holding Tank			
Overboard Pump	Two (2)		

Discussion

The system is not a viable candidate.

The Chrysler Option A components, a minimum gray water holding tank (similar to System Nos. 1 and 2), the Sludge Surge Tank and the pumps can be fitted in the compartment. However, there is insufficient room for the incinerator installation.

Vessel: VIGOROUS (210')

WMS No. 4 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Holding Tank for Black Water/ Holding Tank for Gray Water

	Required
Sewage Influent Surge Tank	313 gal. (42 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sludge Holding Tank	452 gal. (60 cu. ft.)
Grumman Unit without Incinerator	One (1)
Influent Surge Tank Pump	One (1)
Influent Surge Tank Overboard Pump	Two (2)
Galley/Turbid Holding Tank Overboard Pump	Two (2)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system is not a viable candidate.

Due to the quantity and configuration of the equipment required and the piping involved, there appears to be insufficient space available for a functional arrangement and for maintenance and repair in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 5 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Holding Tank for Combined Black and Gray Waters

	Required
Influent Surge Tank	1235 gal. (165 cu. ft.)
Sludge Holding Tank	1742 gal. (233 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Influent Surge Tank Pump	Two (2)
Influent Surge Tank Overboard Pump	Two (2)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required especially due to the space required by the Grumman MSD's in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 6 Full Volume Flush Gravity Collection/Holding Tank for Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water

	Required
G/T Influent Surge Tank	922 gal. (123 cu. ft.)
Sewage Holding Tank	5,418 gal. (724 cu. ft.)
Sludge Holding Tank	1,290 gal. (172 cu. ft.)
Optional Combined Sewage/ Sludge Holding Tank	6,708 gal. (897 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Sewage Holding Tank Overboard Pump	Two (2)
Influent Surge Tank Pump	Two (2)
Influent Surge Tank Transfer Pump	One (1)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system is not a viable candidate.

There is insufficient space available in the existing Sewage Treatment Space on the Third Deck for anything other than a partial capacity Sewage Holding Tank and its overboard/pierside pumps.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 7 **Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Incinerator for Black Water/Holding Tank for Gray Water**

	Required
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sewage Influent Surge Tank	313 gal. (42 cu. ft.)
Fuel Oil Day Tank	25 gal. (3.3 cu. ft.)
Grumman Units with Incinerator	One (1) with One (1) Thiokol
Influent Surge Tank Pump	One (1)
Influent Surge Tank Overboard Pump	Two (2)
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, especially due to the space required by the Grumman MSD in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 8 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Incinerator for Combined Black and Gray Waters

	Required
Influent Surge Tank	1,235 gal. (165 cu. ft.)
Fuel Oil Day Tank	25 gal. (3.3 cu. ft.)
Grumman Units with Incinerators	Two (2) with Two (2) Thiokol Incinerators
Influent Surge Tank Pump	Two (2)
Influent Surge Tank Overboard Pump	Two (2)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, especially due to the space required by the Grumman MSD s with their incinerators in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 9 JERED Reduced Volume Flush Vacuum Collection/Holding Tank for Concentrated Black Water/Holding Tank for Gray Water

	Required
Vacuum Collection Tank Ass'y	250 gal. (165 cu. ft.)
Sewage Holding Tank	1,540 gal. (206 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sanitary Holding Tank Overboard Pump	Two (2)
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system is considered to be a viable candidate subject to certain limitations.

Re-use of existing piping arrangements would have to be considered. A fresh water sanitary flushing system would be required.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) Due to space limitations the Sewage Holding Tank would be restricted to 740 gallons (99 cu. ft.), approximately 5'-6" L x 3' W x 6' H, located in the aft end of the compartment, port side.

(b) The minimum gray water holding tank discussed in System No. 1 would be located at the forward end of the compartment, port side.

(c) The vacuum collection tank assembly would be located at the forward end of the compartment, starboard side.

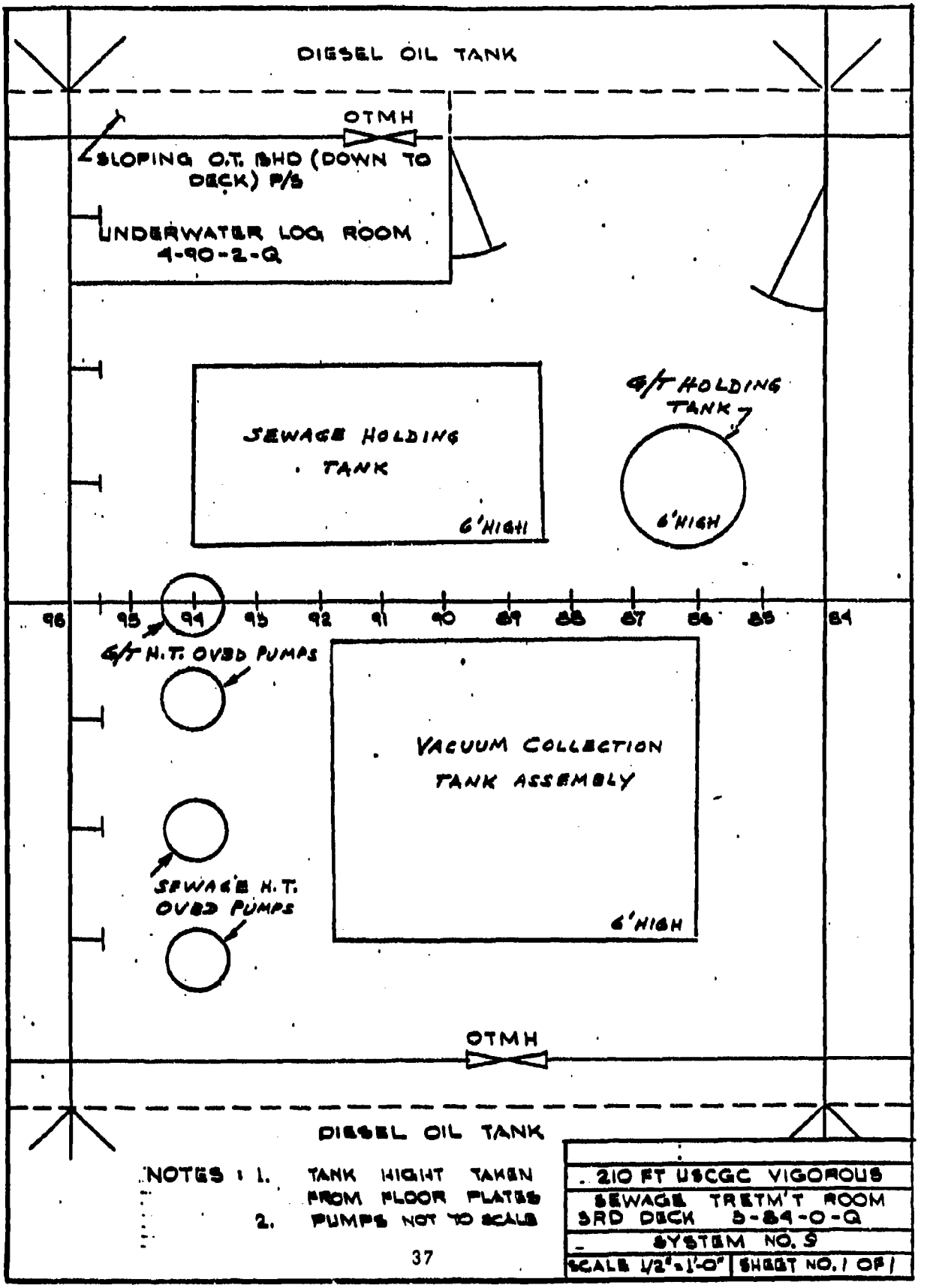
(d) The various overboard/pierside discharge pumps would be located at the aft end of the compartment, starboard side.

Drainage would be as follows:

(a) Sewage from all spaces would be collected by vacuum in the vacuum collection tank assembly. The garbage grinder drains would require a special vacuum valve similar to a urinal discharge type valve to permit proper collection.

(b) Galley and Turbid drains would gravitate to the small gray water holding tank for discharge overboard in unrestricted water and to the Sewage Holding Tank or pierside when overboard discharge is not permitted.

PROPOSED WMS EQUIPMENT ARRANGEMENT



NOTES : 1. TANK HIGHT TAKEN FROM FLOOR PLATES
2. PUMPS NOT TO SCALE

210 FT USCGC VIGOROUS
SEWAGE TRETM'T ROOM 3RD DECK 5-84-0-Q
SYSTEM NO. 9
SCALE 1/2"=1'-0" | SHEET NO. 1 OF 1

WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 9

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	2,230 [2]	10,035
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	2,080 [4]	1,144
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	1,730 [5]	1,592
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)	375	750
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)	35	525
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)	55	55
Welding		Feet	$ 6.00/Ft. (Materials and Labor)	65	390
Removals	Cutting	Hours	$50.00/Hr. [6] (Labor)	25	1,250
	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)					16,266

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 60 ft./hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 10 JERED Reduced Volume Flush Vacuum Collection/Incinerator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Vacuum Collection Tank Assembly	250 gal. (165 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Fuel Oil Day Tank	61 gal. (8.2 cu. ft.)
Incinerator	One (1) Jered
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system is a viable candidate subject to certain limitations.

Re-use of existing piping arrangements would have to be considered. A fresh water sanitary flushing system would be required.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) The vacuum collection tank assembly would be fitted at the aft end of the compartment, predominantly to port.

(b) The incinerator, blower and fuel oil day tank would be fitted to starboard of the vessel's centerline.

(c) The vessel does not have a stack, since the diesel engine exhausts run aft to the weather via the transom stern. This apparently will offer complications as to if and how the incinerator stack can be satisfactorily led to the weather. See the Special Remarks in the discussion at the beginning of this Section. Fire fighting protection and possibly the space ventilation will have to be modified.

(d) A minimum gray water holding tank (approximately 2'-3" L x 1'-6" W x 6' H) would be fitted at the forward end, port side.

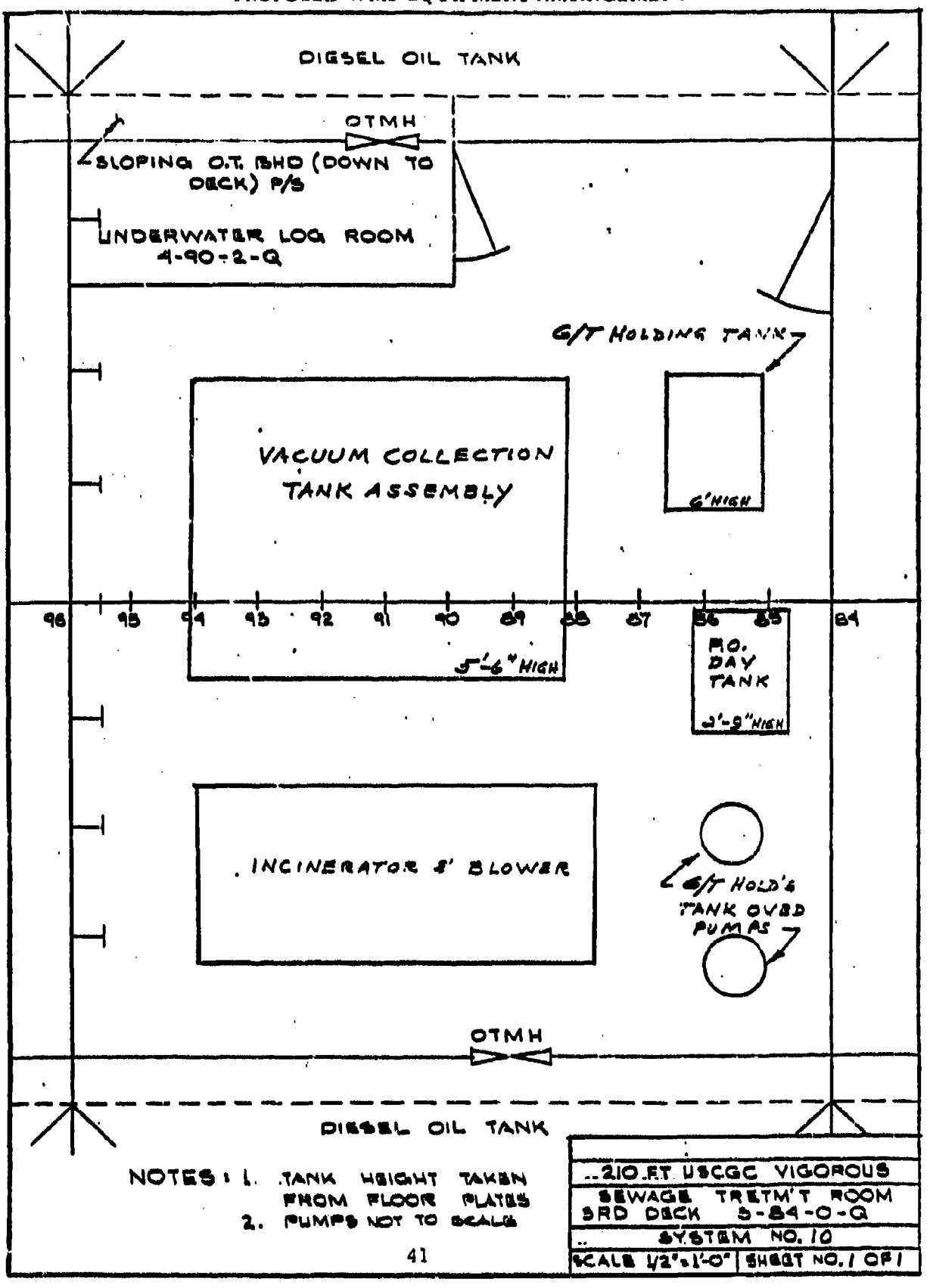
(e) The gray water holding tank pump would be located in the forward starboard corner.

Drainage would be as follows:

(a) Sewage from all spaces would be collected by vacuum in the vacuum collection tank assembly. The garbage grinder drains would require a special vacuum valve similar to a urinal discharge type valve to permit proper collection.

(b) Galley and Turbid drains would gravitate to the small gray water holding tank for discharge overboard and to pierside.

PROPOSED WMS EQUIPMENT ARRANGEMENT



NOTES: 1. TANK HEIGHT TAKEN FROM FLOOR PLATES
2. PUMPS NOT TO SCALE

..210.FT USCGC VIGOROUS
SEWAGE TRETM'T ROOM 3RD DECK 5-84-0-Q
.. SYSTEM NO. 10
SCALE 1/2"=1'-0" | SHEET NO. 1 OF 1

WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 10

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	4,265 [2]	19,193
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	460 [4]	253
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	1,175 [5]	1,081
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)	225	450
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)	20	300
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)	55	55
Welding		Feet	$ 6.00/Ft. (Materials and Labor)	70	420
Removals	Cutting	Hours	$50.00/Hr. [6] (Labor)	25	1,250
	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)					23,527

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft./hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 11 JERED Reduced Volume Flush Vacuum Collection/GATX Evaporator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Vacuum Collection Tank Assembly	250 gal. (165 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Evaporator (GATX)	Three (3)-60 gal.
Catalytic Oxidizer	Three (3)
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, especially due to the space required to fit all the evaporators and their piping in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 12 JERED Reduced Volume Flush Vacuum Collection/Holding Tank for Concentrated Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water

	Required
G/T Influent Surge Tank	922 gal. (123 cu. ft.)
Sludge Holding	1,290 gal. (172 cu. ft.)
Vacuum Collection Tank Assembly	250 gal. (165 cu. ft.)
Sewage Holding Tank	1,540 gal. (206 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Influent Surge Tank Pump	Two (2)
Sewage Holding Tank Overboard Pump	Two (2)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, especially due to the space required by the vacuum collection assembly plus the Grumman installations, all in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 13 JERED Reduced Volume Flush Vacuum Collection/Grumman Flow Through System for Gray Water/Incinerator for both Concentrated Black Water and Gray Water Sludge

	Required
Galley/Turbid Influent Surge Tank	922 gal. (123 cu. ft.)
Vacuum Collection Tank assembly	250 gal. (165 cu. ft.)
Fuel Oil Day Tank	112 gal. (15 cu. ft.)
Grumman Unit with Incinerators	Two (2) with Three (3) Thiokol Incinerators
Vacuum Collection Tank Transfer Pumps	Three (3)
Influent Surge Tank Pumps	Two (2)
G/T Holding Tank Overboard Pump	Two (2)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, expecially due to the space required by the vacuum collection assembly plus the Grumman installations with multiple incinerators, all in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 14 GATX Reduced Volume Flush M/T Pump Collection/Holding Tank for Concentrated Black Water/Holding Tank for Gray Water

	Required
Sewage Holding Tank	1,742 gal. (233 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sewage Holding Tank Overboard Pump	Two (2)
G/T Holding Tank Overboard Pump	Two (2)
Macerator/Transfer Pump	Nine (9)

Discussion

The system installation is a viable candidate subject to certain limitations.

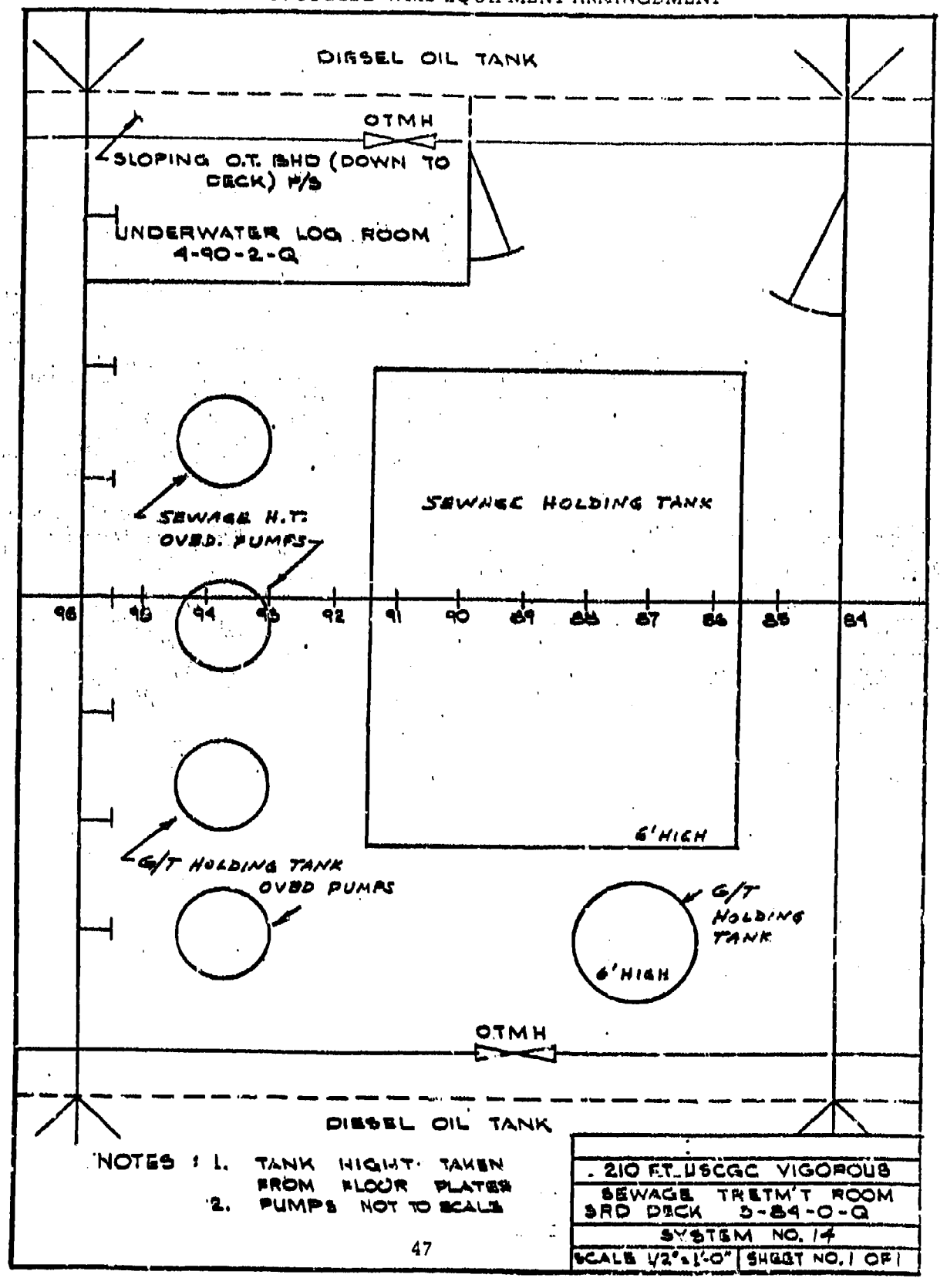
A fresh water sanitary flushing system would be required.

The system is similar to System No. 1 except that sewage collection for this system is by macerator/transfer pumps instead of gravity.

The Sewage Holding Tank required capacity can apparently be met in a tank approximately 6' L x 8' W x 6' H.

The equipment arrangement would be as indicated for System No. 1.

PROPOSED WMS EQUIPMENT ARRANGEMENT



WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 14

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	1,285 [2]	5,783
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	4,010 [4]	2,206
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	2,410 [5]	2,218
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)	300	600
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)	35	525
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)	55	55
Welding		Feet	$ 6.00/Ft. (Materials and Labor)	80	480
Removals	Cutting	Hours	$50.00/Hr. [6] (Labor)	25	1,250
	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)					13,642

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft./hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210)

WMS No. 15 GATX Reduced Volume Flush M/T Pump Collection/Incinerator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Incinerator Feed Tank	125 gal. (17 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Fuel Oil Day Tank	61 gal. (8.2 cu. ft.)
Incinerator	One (1) Jered
Incinerator Feed Pump	One (1)
Incinerator Feed Tank Overboard Pump	One (1)
G/T Holding Tank Overboard Pump	Two (2)
Macerator/Transfer Pump	Nine (9)

Discussion

The system installation is a viable candidate subject to certain limitations.

A fresh water sanitary flushing system would be required.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) The incinerator feed tank (approximately 2' L x 2' W x 4'-6" H) would be located on the port side, aft.

(b) The incinerator, blower, feed pump and fuel oil day tank would be located on the starboard side.

As far as an incinerator stack is concerned, see System No. 10 for running the stack to the weather.

Fire fighting protection and possibly the space ventilation will have to be modified.

(c) Due to lack of more space, the galley/turbid holding tank would be restricted to 538 gallons (72 cu. ft.), approximately 4' L x 3' W x 6' H. It would be located on the port side, forward.

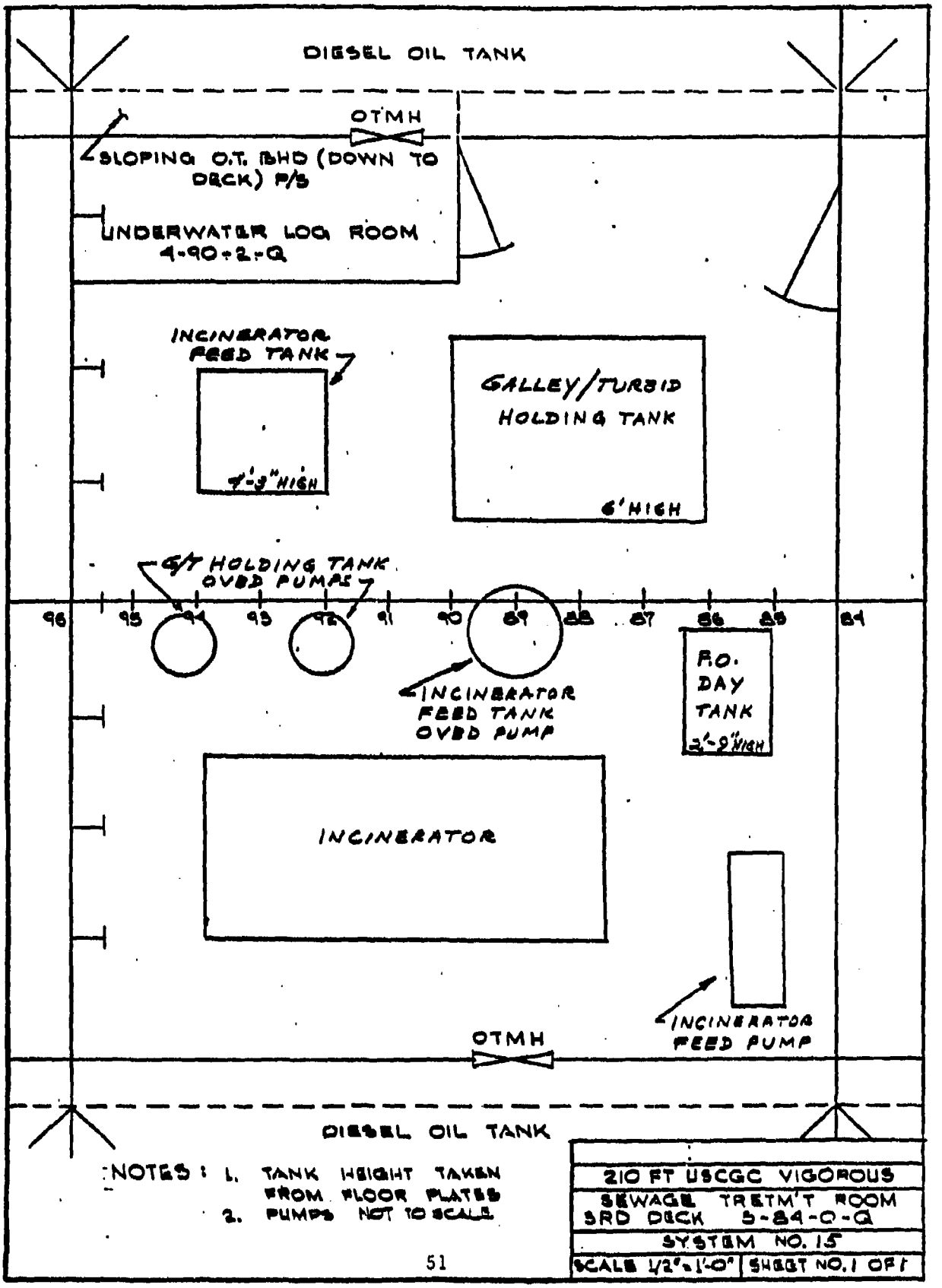
(d) The pumps associated with the equipment would be located along the vessel's centerline.

Drainage would be as follows:

(a) All sewage would be collected by macerator/transfer pumps and discharged to the incinerator feed tank. Pumps would either feed it to the incinerator or discharge it overboard or pierside according to prevailing restrictions.

(b) Galley/turbid water would gravitate to the G/T holding tank from which it would be pumped either overboard or to pierside.

PROPOSED WMS EQUIPMENT ARRANGEMENT



NOTES: 1. TANK HEIGHT TAKEN FROM FLOOR PLATES
2. PUMPS NOT TO SCALE

210 FT USCGC VIGOROUS
SEWAGE TRETM'T ROOM 3RD DECK 5-84-0-Q
SYSTEM NO. 15
SCALE 1/2"=1'-0" | SHEET NO. 1 OF 1

WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 15

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	3,335 [2]	15,008
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	2,345 [4]	1,290
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	1,095 [5]	1,008
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)	375	750
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)	35	525
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)	55	55
Welding		Feet	$ 6.00/Ft. (Materials and Labor)	80	480
Removals	Cutting	Hours	$50.00/Hr. [6] (Labor)	25	1,250
	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)					20,891

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft. /hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 16 GATX Reduced Volume Flush M/T Pump Collection/GATX Evaporator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Evaporator Feed Tank	125 gal. (16.7 cu. ft.)
Evaporator (GATX)	Three (3) - 60 gal.
Catalytic Oxidizer	Three (3)
Evaporator Feed Pump	Two (2)
Evaporator Feed Tank Overboard Pump	One (1)
G/T Holding Tank Overboard Pump	Two (2)
Macerator/Transfer Pump	Nine (9)

Discussion

The system installation is a viable candidate subject to certain limitations.

Equipment could be located in the existing Sewage Treatment Space on the Third Deck. The installation will be a little on the tight side depending on how the final piping arrangement is installed, since a number of components would have to be fitted on this rather small space.

A fresh water sanitary flushing system would be required.

Equipment could be arranged as follows:

(a) The evaporator feed tank (approximately 2' L x 2' W x 4'-3" H) would be on the port side, aft.

(b) The evaporators and their vapor treatment equipment would be located one on the vessel's centerline forward and two on the starboard side.

(c) The minimum gray water holding tank discussed in System No. 1 would be located on the port side, just forward of the evaporator feed tank.

(d) The evaporator feed pumps and the various overboard discharge pumps would be arranged functionally near the equipment served.

Drainage would be as follows:

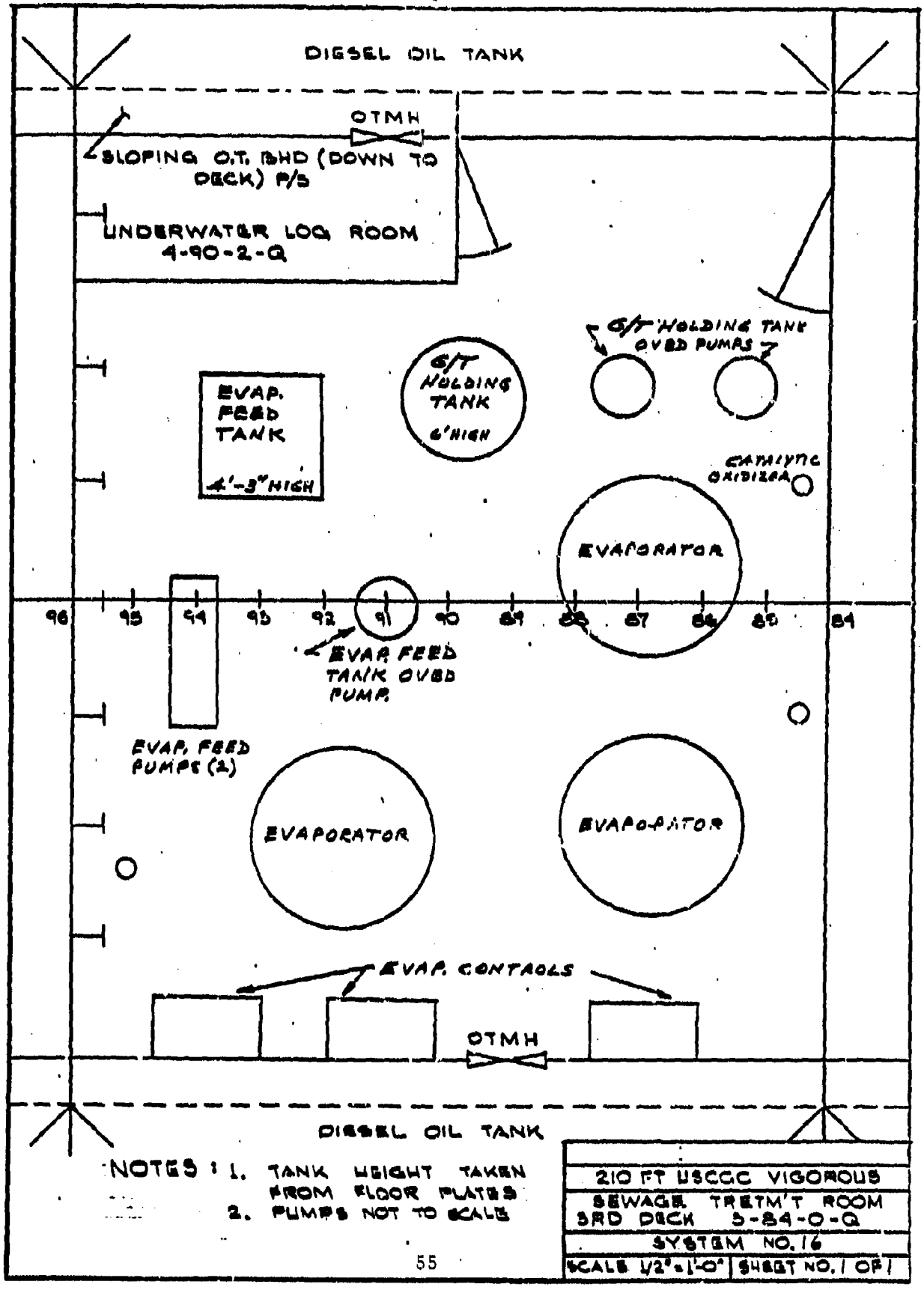
(a) All sewage would be collected by macerator/transfer pumps and discharged to the evaporator feed tank.

(b) Sewage would be pumped either to the evaporators or to overboard or pierside connections depending on prevailing restrictions.

(c) Sludge from the evaporators would be pumped overboard.

(d) Galley and turbid water would gravitate to the minimum gray water holding tank for discharge either overboard or to pierside connections, depending on restrictions.

PROPOSED WMS EQUIPMENT ARRANGEMENT



NOTES: 1. TANK HEIGHT TAKEN FROM FLOOR PLATES
2. PUMPS NOT TO SCALE

210 FT USCGC VIGOROUS
SEWAGE TRETM'T ROOM 3RD DECK 5-84-0-Q
SYSTEM NO. 16
SCALE 1/2"=1'-0" | SHEET NO. 1 OF 1

WMS INSTALLATION COST ESTIMATES

Vessel VIGOROUS (210')

WMS No. 16

Installation Cost Element		Unit	Assumed Unit Cost	Quantity Required (estimated number of units)	Cost ($)
Piping[1]		Pounds	$ 4.50/Lb. (Materials and Labor)	1,585[2]	7,133
Tank Steel[3]		Pounds	$ .55/Lb. (Materials and Labor)	500[4]	275
Foundations		Pounds	$ .92/Lb. (Materials and Labor)	515[5]	474
Electric Cables		Feet	$ 2.00/Ft. (Materials and Labor)	450	900
Miscellaneous Installations (pumps, motors, skid-mounted components, etc.)		Man-Hours	$15.00/MH (Labor)	35	525
Access Cuts (in hull, deck plating or bulkhead to provide passageway)		Feet	$ 1.00/Ft. (Labor)	55	55
Welding		Feet	$ 6.00/Ft. (Materials and Labor)	70	420
Removals	Cutting	Hours	$50.00/Hr.[6] (Labor)	25	1,250
Removals	Other (miscellaneous handling)	Man-Hours	$15.00/MH (Labor)	35	525
Total Installation Cost ($)					11,557

(1) Copper-nickel assumed.
(2) Estimate includes a factor of 50% added to allow for valves, flanges, fittings, take-down joints, etc.
(3) One-quarter inch plate assumed.
(4) Estimate includes a factor of 30% added to allow for required structural stiffening for proper support.
(5) Estimated on the basis of 10% of the weight which has to be supported.
(6) Based on an assumed cutting rate of 50 ft./hr.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 17 GATX Reduced Volume Flush M/T Pump Collection/Holding Tank for Concentrated Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water

	Required
Sewage Holding Tank	1,742 gal. (233 cu. ft.)
Galley/Turbid Influent Surge Tank	922 gal. (123 cu. ft.)
Sludge Holding Tank	1,290 gal. (172 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Sewage Holding Tank Overboard Pump	Two (2)
G/T Influent Surge Tank Pump	Two (2)
G/T Influent Surge Tank Transfer Pump	One (1)
Sludge Holding Tank Transfer Pump	Two (2)
Maccrator/Transfer Pump	Nine (9)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, especially due to the space required by the Sewage Holding Tank and the Grumman MSD's in the existing Sewage Treatment Space on the Third Deck.

DISCUSSION OF INSTALLATION BASED ON SHIPCHECKS

Vessel: VIGOROUS (210')

WMS No. 18 GATX Reduced Volume Flush M/T Pump Collection/Grumman Flow Through System for Gray Water/Incinerator for both Concentrated Black Water and Gray Water Sludge

	Required
Sewage Surge Tank	122 gal. (16 cu. ft.)
Galley/Turbid Surge Tank	922 gal. (123 cu. ft.)
Fuel Oil Day Tank	112 gal. (15 cu. ft.)
Grumman Unit with Incinerators	Two (2) with Three (3) Thiokol Incinerators
Sewage Surge Tank Transfer Pump	Three (3)
Sewage Surge Tank Overboard Pump	One (1)
G/T Surge Tank Pump	Two (2)
G/T Surge Tank Overboard Pump	One (1)
Macerator/Transfer Pump	Nine (9)

Discussion

The system is not a viable candidate.

There is insufficient space to include all the equipment required, especially due to the sizes of the Grumman MSD's in the existing Sewage Treatment Space on the Third Deck.

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210') Sheet 1 of 10

Starter/Subfactor Identif. No.

M/E I - ADAPTABILITY FOR SHIPBOARD INSTALLATION

INSTALLATION CHARACTERISTIC

111 Required black water handling capacity for vessel versus actual capacity of WMS

(a) Actual capacity of WMS equals or exceeds required capacity for vessel.
(b) WMS marginally suitable for vessel (has 95-99% of required capacity).
(c) WMS capacity insufficient for vessel (less than 95% of required capacity).

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	c	c	N/A	N/A	N/A	N/A	N/A	N/A	c	a	N/A	N/A	N/A	a	a	a	N/A	N/A

112 Required gray water handling capacity for vessel versus actual capacity of WMS

(a) Actual capacity of WMS equals or exceeds required capacity for vessel.
(b) WMS marginally suitable for vessel (has 95-99% of required capacity).
(c) WMS capacity insufficient for vessel (less than 95% of required capacity).

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	c	c	N/A	N/A	N/A	N/A	N/A	N/A	c	c	N/A	N/A	N/A	c	c	c	N/A	N/A

13 Extent of additional support systems or equipment required to accommodate WMS(1)

(a) No additional support systems or equipments required.
(b) Some additional support systems or equipments required.(2)
(c) Many additional support systems or equipments required.(3)

(1) Examples: . Firefighting system must be installed with incinerator.
. Bilge alarm required if large tank is installed above bilge.
. Compressor required on vessels that do not already have one.
. Detectors of toxic or noxious gases should be installed with any system that, as an inherent design feature, uses such gases in processing wastes.

(2) Need for support system/equipment does not significantly reduce WMS suitability for on-board installation.
(3) Suitability of WMS for installation on vessel significantly reduced.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	b	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	b	b	N/A	N/A

21 Extent of fixture modifications required for WMS installation

(a) No fixtures need modification or replacement.
(b) Some fixtures need modification or replacement.
(c) All commodes need replacement and modification of urinal-associated equipment (e.g., urinal discharge valves) is required.
(d) All fixtures need replacement or modification (e.g., replacement or commodes and urinal flushometers).
(e) All fixutres need replacement or modification and each fixture has additional hookup requirements associated with it.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	c	c	N/A	N/A	N/A	e	e	e	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210') Sheet 2 of 10

Factor/Subfactor/Item, No.

M/E I - ADAPTABILITY FOR SHIPBOARD INSTALLATION (Cont'd)

INSTALLATION CHARACTERISTIC

22 Extent of flush medium supply modifications required for WMS installation

(a) Existing flush medium is used.
(b) WMS requires conversion of flush medium to potable water.
(c) WMS requires conversion of flush medium to recirculating non-aqueous medium.
(d) WMS requires conversion of flush medium to salt water.(1)

(1) Conversion to salt water requires pump re-sizing, tapping into the sea-chest and provision for its corrosive properties. For PAMLICO, salt water would be used if the drain system were converted to a standard flush system (C.G. supplied information).

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	c	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	b	b	N/A	N/A

231 Hookup requirements(1) for WMS Collection/Transport subsystem installation

(a) No additional hookup requirements beyond existing ones.
(b) Requires piping for recirculation of flush medium (in existing gravity drain system).
(c) Special and centralized Collection/Transport subsystem required.
(d) Special and non-centralized Collection/Transport subsystem required (includes conversion from reduced flush vacuum collection to a standard gravity drain system, with or without recirculation).

(1) Drain piping; electric cables connecting commode, M/T pump and control panel in GATX, but not in JERED, etc.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	b	N/A	N/A	N/A	N/A	N/A	N/A	c	c	N/A	N/A	N/A	d	d	d	N/A	N/A

232 Routing flexibility for drain piping modifications(1) associated with WMS Collection/Transport subsystem installation(2)

(a) Routing is highly flexible.(3)
(b) Routing is moderately flexible, with some restrictions.
(c) Routing is highly inflexible.

(1) Of the three relevant categories of routing of lines (piping, ventilation, electrical), piping is the most important for assessing use of WMS installation.

(2) Notes: . With gravity drainage, lines must always slope downward and require venting.
. Smaller size lines are inherently more flexible.
. With the pump or vacuum Collection/Transport subsystem, sharp bends, rises and long runs can be accommodated in piping.

(3) In all cases, WMS installation is to be considered from the point of view of modifications required to existing conditions.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	b	b	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210') Sheet 3 of 10

Factor/Subfactor Ident. No.

M/E I - ADAPTABILITY FOR SHIPBOARD INSTALLATION (Cont'd)

INSTALLATION CHARACTERISTIC

233 Space requirements for WMS Collection/Transport subsystem installation.

(a) No additional space required.(1)
(b) Some additional space required.(2)
(c) Large amount of additional space required.

(1) E.g., M/T pumps in GATX; or small influent surge tank.
(2) E.g., large VCT in JERED; or large influent surge tank, if not already installed.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	a	a	a	N/A	N/A

234 Modularity of WMS Collection/Transport subsystem (as it affects installation)(1)

(a) Degree of modularity of subsystem aids in installation of C/T subsystem.
(b) Degree of modularity of subsystem results in some (minimal) difficulty in installation of C/T subsystem.
(c) Degree of modularity of subsystem results in moderate difficulty in installation of C/T subsystem.

(1) On vessels that do not currently have a WMS, a high degree of modularity aids in installation, and a high degree of subsystem centralization (as in the JERED) results in difficulties for installation.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	a	a	a	N/A	N/A

235 Vent requirements for WMS Collection/Transport subsystem installation

(a) No vents are required other than the existing vents.
(b) Few vents are required in addition to the existing vents.
(c) Many vents are required in addition to existing vents.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	a	a	b	N/A	N/A

241 Space requirements for WMS waste Treatment/Disposal subsystem installation

(a) Volume required is minimal and dimensions(1) of equipment present no problems in fitting equipment into available compartment space.
(b) Volume required is moderate and dimensions(1) of equipment present no problems in fitting equipment into available compartment space.
(c) Volume and dimension(1) of equipment do present problem in fitting equipment into available compartment space.
(d) Large volume required and dimension(1) of equipment do present problem in fitting equipment into available compartment space.

(1) The two main factors are (i) deck area required and (ii) height required.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	a	b	c	N/A	N/A

Factor/Subfactor Ident. No.

M/E I - ADAPTABILITY FOR SHIPBOARD INSTALLATION (Cont'd)

INSTALLATION CHARACTERISTIC

242 Hookup requirements[1] for WMS waste Treatment/Disposal subsystem installation

(a) Pipes, ducts and/or cable requirements are minimal.
(b) Pipes, ducts and/or cable requirements are moderate.
(c) Pipes, ducts and/or cable requirements are extensive.

(1) Piping for fuel oil, fresh water, cooling water, compressed air, interconnecting remotely located equipment, overboard discharge line, etc.; electric cables for power supply, remote control panels, etc.; ducting for ventilation, etc.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	c	c	N/A	N/A

243 Degree of modularity of WMS waste Treatment/Disposal (as it affects installation)[1]

(a) Degree of modularity of subsystem aids in installation of T/D subsystem.
(b) Degree of modularity of subsystem results in some (minimal) difficulty in installation of T/D subsystem.
(c) Degree of modularity of subsystem results in moderate difficulty in installation of T/D subsystem.

(1) Decentralization of components may require additional hookups and piping runs.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	b	b	N/A	N/A

244 Vent requirements for WMS waste Treatment/Disposal subsystem installation[1]

(a) No vents are required.
(b) Vents are required.

(1) Vents that are only internal to the compartment in which subsystem is located are not considered here.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	b	b	N/A	N/A

245 Exhaust stack requirements for WMS waste Treatment/Disposal subsystem installation[1]

(a) Exhaust not required.
(b) Exhaust required, size of stack relatively small and stack can be run via existing ship's stack enclosure (fiddley).
(c) Exhaust required, size of stack relatively large and stack can be run via existing ship's stack enclosure.
(d) Exhaust required, size of stack relatively small and stack cannot be run via existing ship's stack enclosure.
(e) Exhaust required, size of stack relatively large and stack cannot be run via existing ship's stack enclosure.

(1) Notes: . Electric incinerator requires small (2") exhaust.
. Fuel incinerator requires large (10") exhaust.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	a	a	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210') Sheet 5 of 10

Factor/Subfactor Ident. No.

M/E I - ADAPTABILITY FOR SHIPBOARD INSTALLATION (Cont'd)

INSTALLATION CHARACTERISTIC

25 Ease of installing WMS support equipment(1)

(a) No support equipment required.
(b) Some support equipment required but easy to install.
(c) Much support equipment required and difficult to install.

(1) Examples:
- Firefighting system must be installed with incinerator.
- Bilge alarm required if large tank is installed above bilge.
- Compressor required on vessels that do not already have one.
- Detectors of toxic or noxious gases should be installed with any system that, as an inherent design feature, uses such gases in processing wastes.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	b	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	b	b	N/A	N/A

26 Ease of compensating for added weight of WMS

(a) No or minimal compensation for added weight required.
(b) Moderate compensation for added weight required.
(c) Extensive compensation for added weight required.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	b	N/A	N/A	N/A	a	b	b	N/A	N/A

271 Extent of SHIPALTS (permanent modifications) required for WMS installation(1)

(a) No SHIPALTS required.
(b) Minor SHIPALTS required.
(c) Extent of SHIPALTS required is moderate.
(d) Extensive SHIPALTS required.

(1) Foundations, enlarged doors/hatches, increased capacity requirements for air compressor, etc.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	d	N/A	N/A	N/A	N/A	N/A	N/A	b	d	N/A	N/A	N/A	b	d	b	N/A	N/A

272 Extent of temporary modification(1) required for WMS installation

(a) No temporary modifications required.
(b) Temporary modifications required are minor.
(c) Extent of temporary modifications required are moderate.
(d) Temporary modifications required are extensive.

(1) Cutting access openings, etc.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	c	c	N/A	N/A	N/A	N/A	N/A	N/A	c	c	N/A	N/A	N/A	c	c	c	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210')

M/E I - ADAPTABILITY FOR SHIPBOARD INSTALLATION (Cont'd)

INSTALLATION CHARACTERISTIC

31 Effect of WMS on vessel stability

(a) No effect on existing stability characteristics of vessel.
(b) Some effect on existing stability characteristics of vessel, easily compensated for.
(c) Severe effect on existing stability characteristics of vessel, compensation required extensive modifications to vessel (e.g., no tankage in Point Herron).

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	a	a	N/A	N/A

32 Effect of WMS on vessel trim and list

(a) No effect on trim or on list.
(b) Some easily compensated for effect on trim or list.
(c) Compensation for effect on trim or list requires extensive modification to vessel.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	a	a	N/A	N/A

33 Effect of WMS on normal range of vessel

Vessel resource capacity and usage rates.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data						- Presented on Vessel Resource Data Sheets -												

34 Degree of space trade-off/reallocation required for WMS installation

(a) No space trade-off/reallocation required.
(b) Minimal degree of space trade-off/reallocation required.
(c) Moderate degree of space trade-off/reallocation required.
(d) High degree of space trade-off/reallocation required.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	a	a	N/A	N/A

M/E II - PERFORMANCE

PERFORMANCE CHARACTERISTIC

12 WMS per capita wet weight (lb)[1] - W_i

[1] Drain piping material is assumed to be copper-nickel (Cu-Ni).

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	570	355	N/A	N/A	N/A	N/A	N/A	N/A	472	419	N/A	N/A	N/A	641	440	321	N/A	N/A

M/E Ii - PERFORMANCE (Cont'd)

Factor/Subfactor Ident. No. / PERFORMANCE CHARACTERISTIC

13 WMS per capita volume (ft^3)(1) - V_i

(1) Volumes are calculated as follows:
- Fixture volumes are calculated using smallest space envelopes.
- Pipe volume is the volume of a square tube with side = outside diameter of pipe.
- Other equipment: Deck area: smallest rectangle enclosing all equipment in a single package plus extra dimension area required for operation and maintenance.
  Height: either maximum height of equipment, or full compartment height, if space above package is not usable for any other purposes.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	20.0	21.1	N/A	N/A	N/A	N/A	N/A	N/A	21.2	21.8	N/A	N/A	N/A	21.4	22.0	29.0	N/A	N/A

21 Adequacy of WMS black water holding times

HT_b = % of required black water holding time met by WMS(1)

(1) A WMS which employs an incinerator is considered to meet 100% of the required holding time. The holding time of a WMS which employs a holding tank (for wastewater or sludge) is determined by the ratio of available tank capacity to required capacity.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	40	53	N/A	N/A	N/A	N/A	N/A	N/A	48	100	N/A	N/A	N/A	100	100	100	N/A	N/A

22 Adequacy of WMS gray water holding times

HT_g = % of required gray water holding time met by WMS(1)

(1) A WMS which employs an incinerator is considered to meet 100% of the required holding time. The holding time of a WMS which employs a holding tank (for wastewater or sludge) is determined by the ratio of available tank capacity to required capacity.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	1	1	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	N/A	N/A	1	3	1	N/A	N/A

311 Effect of peak hydraulic loads in black water stream on WMS performance

$GIST_b$ = % of required Grumman (or other) influent surge tank capacity in black water stream met by installation.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	--	--	N/A	N/A	N/A	N/A	N/A	N/A	--	--	N/A	N/A	N/A	--	--	--	N/A	N/A

312 Effect of peak hydraulic loads in gray water stream on WMS performance

$GIST_g$ = % of required Grumman influent surge tank capacity in gray water stream met by installation.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	--	N/A	N/A	N/A	--	--	--	N/A	N/A

331 Ability of black water portion of WMS to handle additional personnel (on a long-term basis)

HTC_b = % of required black water (or sludge) holding tank capacity met by installation.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	40.	53	N/A	N/A	N/A	N/A	N/A	N/A	48	--	N/A	N/A	N/A	100	--	--	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210') Sheet 8 of 10

Factor/Subfactor Ident. No.	M/E II - PERFORMANCE (Cont'd)																	
	PERFORMANCE CHARACTERISTIC																	
332	Ability of gray water portion of WMS to handle additional personnel (on a long term basis) HTC_g = % of required gray water (or sludge) hodling tank capacity met by installation.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	1	1	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	N/A	N/A	1	3	1	N/A	N/A
	M/E IV - PERSONNEL SAFETY																	
	SAFETY CHARACTERISTIC																	
21	Hazard of explosive potential for operator/maintainer due to inherent WMS design. I - Installation index (for personnel safety) (a) Likelihood of hazardous situation is not increased due to location of any portion of WMS. (b) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to working or berthing area. (c) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to fuel storage area.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	c	N/A	N/A	N/A	a	c	a	N/A	N/A
22	Hazard of explosive potential for operator/maintainer due to procedural error/equipment failures of WMS. I - Installation index (for personnel safety) (a) Likelihood of hazardous situation is not increased due to location of any portion of WMS. (b) Likelihood of hazardous situatio.. is increased due to proximity of any portion of WMS to working or berthing area. (c) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to fuel storage area.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	c	N/A	N/A	N/A	a	c	a	N/A	N/A
31	Hazard of fire ignition potential due to inherent WMS design I - Installation index (for personnel safety) (a) Likelihood of hazardous situation is not increased due to location of any portion of WMS. (b) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to working or berthing area. (c) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to fuel storage area.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	c	N/A	N/A	N/A	a	c	a	N/A	N/A
32	Hazard of fire ignition potential due to procedural errors/equipment failures of WMS. I - Installation index (for personnel safety) (a) Likelihood of hazardous situation is not increased due to location of any portion of WMS. (b) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to working or berthing area. (c) Likelihood of hazardous situation is increased due to proximity of any portion of WMS to fuel storage area.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	c	N/A	N/A	N/A	a	c	a	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210')

M/E V - HABITABILITY

Factor/Subfactor Identif. No.	HABITABILITY CHARACTERISTIC
41	Heat generation for nearby personnel[1] due to inherent WMS design I - Installation Index (for heat) (a) Location of WMS is not likely to raise heat level due to proximity to working and berthing areas. (b) Location of WMS is likely to raise heat level due to proximity to working and berthing areas. [1] For operator/maintainer/adjacent berthing and working areas.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	b	N/A	N/A	N/A	a	b	a	N/A	N/A

42	Heat generation for nearby personnel[1] due to procedural errors/equipment failures of WMS I - Installation Index (for heat) (a) Location of WMS is not likely to raise heat level due to proximity to working and berthing areas. (b) Location of WMS is likely to raise heat level due to proximity to working and berthing areas. [1] For operator/maintainer/adjacent berthing and working areas.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	b	N/A	N/A	N/A	a	b	a	N/A	N/A

5	Noise level for personnel in vicinity of WMS[1] I - Installation Index (for noise) (a) Location of WMS is not likely to raise noise level due to proximity to working and berthing areas. (b) Location of WMS is likely to raise noise level due to proximity to working and berthing areas. [1] For operator/maintainer/adjacent berthing and working areas.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	a	a	N/A	N/A

6	Vibration levels for nearby personnel[1] produced by WMS machinery I - Installation Index (for vibration) (a) Location of WMS is not likely to raise vibration level due to proximity to working and berthing areas. (b) Location of WMS is likely to raise vibration level due to proximity to working and berthing areas. [1] For operator/maintainer/adjacent berthing and working areas.

WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	a	a	N/A	N/A	N/A	N/A	N/A	N/A	a	a	N/A	N/A	N/A	a	a	a	N/A	N/A

WMS INSTALLATION EFFECTIVENESS ATTRIBUTE DATA

Vessel VIGOROUS (210')

Factor/Subfactor Ident. No.																		
M/E VI - RELIABILITY																		
RELIABILITY CHARACTERISTIC																		
22	Extent of WMS configuration redundancy WMS equipment requirements.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data					" Presented on WMS Equipment Requirements Data Form "													
M/E VII - MAINTAINABILITY																		
MAINTAINABILITY CHARACTERISTIC																		
151	Accessibility of replaceable WMS components I - Installation index (for accessibility) (a) High degree of physical clearance around WMS equipment. (b) Moderate degree of clearance around WMS equipment. (c) Very tight, i.e., very little clearance around WMS equipment.																	
WMS #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Data	b	b	N/A	N/A	N/A	N/A	N/A	N/A	b	b	N/A	N/A	N/A	b	c	c	N/A	N/A

CONCLUDING REMARKS

The following are points of consideration and observation relevant to this vessel, some of which have been included in the shipcheck observations, and are reiterated for emphasis and convenience.

(a) The vessel in presently fitted with a CHT system, components of which are located in the Sewage Treatment Space (3-84-0-Q) on the Third Deck. Space is very much at a premium on this vessel. The Sewage Treatment Space reflects this condition, although it is adequate for the existing installation. The separate piping mains for black and gray water lead themselves for reuse where size and function permit. Existing piping connections would be reused where possible.

(b) The lack of additional suitable space limits the location of any WMS to the existing compartment. For some of the systems the arrangements envisioned would be considered "tight".

(c) Access to the Sewage Treatment Space for WMS installations appears to the limited to cutting through the ship's side via the fuel oil tankage port or starboard. This would require tank washing and gas freeing.

(d) The vessel is fitted with all support systems with the exception of a fresh water flushing system. The fire portection and ventilation systems would probably require modification to suit systems employing incinerating and other heat producing equipment.

(e) The vessel does not have a conventional stack. All engine exhaust is via horizontal runs aft and out the stern. This complicates matters in that it is difficult to determine how an incinerator stack can be led to the weather (see discussion in shipcheck observations.

(f) There is no ballast system per se. Any weight compensation would have to be by adjustment of existing on-board weights.

(g) Modern compartment joiner work aboard makes it a practical impossibility to assess all the interferences posed by piping, ventilation and air conditioning ducts, wireways etc. This would have to be done at length by a shipyard force.

APPENDIX A

PRELIMINARY INSTALLATION ANALYSIS

VIGOROUS (210')

Vessel Characteristic	Data
Class	WHEC - 627 Resolute (210') B Class
Type	Medium Endurance Cutter
Crew Size	60
Home Port	New London, Connecticut

SUMMARY OF PRELIMINARY INSTALLATION ANALYSIS RESULTS

VIGOROUS (210')

WMS No.	TYPE: Coll/Trans Subsys (Black)	TYPE: Treatment/Disposal Subsystem: Black	TYPE: Treatment/Disposal Subsystem: Gray	SYSTEM ACCEPTABILITY FOR INSTALLATION(1)
1	Gravity Collect.	Holding Tank	Holding Tank	Yes
2	Oil Recircul. (Chrysler)	Chrysler + Hld Tnk	Holding Tank	Yes
3		Chrysler + Incin.	Holding Tank	No
4	Gravity Collect. (Grumman)	Grum Flow Thru+HldTk	Holding Tank	No
5		Grumman Flow Thru + Holding Tank		No
6	Gravity Collect.	Holding Tank	Grum Flow Thru+HldTnk	No
7	Gravity Collect. (Grumman)	Grum Flow Thru+Incin.	Holding Tank	No
8		Grumman Flow Thru + Incinerator		No
9	Vacuum Collect. (Jered)	Holding Tank(2)	Holding Tank	Yes
10		Incinerator	Holding Tank	Yes
11		GATX Evap.	Holding Tank	No
12		Holding Tank(3)	Grum Flow Thru+ Hld Tnk	No
13		Incinerator	Grum Flow Thru + Incin.	No
14	M/T Pump Collect. (GATX)	Holding Tank	Holding Tank	Yes
15		Incinerator	Holding Tank	Yes
16		GATX Evap.	Holding Tank	Yes
17		Holding Tank	Grum Flow Thru+Hld Tnk	No
18		Incinerator	Grum Flow Thru + Incin.	No

(1) Based on:
- Information contained in available vessel plans.
- WMS installation requirements.
- WMS installation criteria and guidelines.

(2) Two subchoices available for WMS No. 9 as follows:
- 9a - Concentrated black water transferred from VCT to holding tank (acceptable for all vessels).
- 9b - Concentrated black water held in VCT (acceptable for Point Herron only).

(3) Two subchoices available for WMS No. 12 as follows:
- 12a - Concentrated black water transferred from VCT to holding tank (acceptable for all vessels).
- 12b - Concentrated black water held in VCT (acceptable for Point Herron only).

PERTINENT VESSEL INFORMATION

VIGOROUS (210')

Crew: 60 Men

Sanitary Fixtures: 17 Watercloset
3 Urinals
19 Lavatories
14 Showers

Existing Arrangement:

The vessel is fitted with separate drainage systems, one for sewage and one for galley and turbid. The system drains from the various spaces are combined with similar drains from other spaces where possible, forming small mains which, in turn, combine and eventually enter the Sewage Treatment Space (3-84-0-Q) on the Third Deck. This space contains a Galley and Turbid tank of approximately 100 gallons capacity and a Sewage Tank of approximately 680 gallons.

The sewage mains enter the sewage tank and the galley/turbid mains enter the galley and turbid tank, but a valved crossover permits gray water to be routed to the sewage tank if necessary. There is no gravitational system overboard. Drains collected in these tanks are pumped overboard and to pierside via special connections in the weather, port and starboard.

There appear to be some spaces which are empty at present but which are identified for future assignments (armament, navigation, etc.). These will be verified at the shipcheck. Otherwise, there does not appear to be much space available for system component installations. Also there is no ship's stack, since engine exhausts are routed aft through the stern. Therefore, running incinerator stacks will require particular investigation.

PRELIMINARY INSTALLATION ANALYSIS OF INDIVIDUAL CANDIDATE SYSTEMS

Vessel: VIGOROUS (210')

WMS No. 1 Full Volume Flush Gravity Collection/Holding Tank for Black Water/Holding Tank for Gray Water

	Required
Sewage Holding Tank	5,418 gal. (724 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sewage Holding Tank Overboard Pump	Two (2)
G/T Holding Tank Overboard Pump	Two (2)

Discussion

The system installation appears to be acceptable subject to certain limitations.

Equipment would be arranged in the existing Sewage Treatment Space (3-84-0-Q) on the Third Deck as follows:

(a) Due to space limitations the Sewage Holding Tank would be restricted to 2154 gallons (288 cu. ft.). The tank would be approximately 6' L x 8' W x 6' H and would straddle the vessel's centerline at the forward end of the compartment.

(b) The galley and turbid drains cannot gravitate overboard since the vessel's waterline is just under the Second Deck level. Therefore, a minimum gray water holding tank would be fitted. The tank would be 150 gallons (20 cu. ft.), approximately 2 feet in diameter by 6 feet high, and located aft and to starboard of the Sewage Holding Tank.

(c) The Sewage Holding Tank Overboard Pump and the Gray Water Holding Tank Overboard Pump would be located at the aft end of the compartment.

Drainage would be as follows:

(a) Sewage from all spaces would gravitate to the Sewage Holding Tank for discharge overboard and pierside via the tank's pumps.

(b) Galley and Turbid water would gravitate to the small gray water holding tank for discharge overboard in unrestricted waters and for pierside discharge.

Vessel: VIGOROUS (210')

WMS No. 2 Full Volume Flush Oil Recirculation and Gravity Collection/ Chrysler System with Sludge Holding Tank for Sewage/Holding Tank for Gray Water

	Required
Sewage Holding Tank	1,011 gal. (135 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)

Chrysler Model and Quantity

	Option A	Option B	Option C
Separation Tank	One (1)-A/B	One (1) A & One (1) A/B	Three (3)-A
Fluid Maintenance and Pump Package	One (1)-A	Two (2)-A	Three (3)-A

Sewage Holding Tank Overboard Pump	Two (2)
G/T Holding Tank Overboard Pump	Two (2)

Discussion

The system installation appears to be acceptable subject to certain limitations.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) Due to space limitations the Sewage Holding Tank would be restricted to 538 gallons (72 cu. ft.), approximately 3' L x 4' W x 6' H, located at the forward starboard end of the compartment.

(b) The minimum gray water holding tank discussed in System No. 1 would be located in the aft starboard corner of the compartment.

(c) There is room only for Chrysler Option A. The components would be fitted along the ship's centerline, with the Separation Tank aft.

(d) The tank overboard discharge pumps would be located aft of the Sewage Holding Tank.

Drainage would be as follows:

(a) Sewage from all spaces except the garbage grinder would gravitate to the Chrysler Separation Tank.

(b) Garbage grinder drains would gravitate to the Sewage Holding Tank.

(c) Galley/Turbid drains would gravitate to the small gray water holding tank for discharge overboard in unrestricted waters and to the Sewage Holding Tank or pierside when overboard discharge is not permitted.

Vessel: VIGOROUS (210')

WMS No. 3 Full Volume Flush Oil Recirculation and Gravity Collection/ Chrysler System with Incinerator for Sewage/Holding Tank for Gray Water

	Required		
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)		
Sludge Surge Tank	One (1) - Model B		
Incinerator Model and Quantity	One (1) - Model C		
Chrysler Model and Quantity	**Option A**	**Option B**	**Option C**
Separation Tank	One (1)-A/B	One (1)-A One (1)-A/B	Three (3)-A
Fluid Maintenance and Pump Package	One (1) - A	Two (2)-A	Three (3)-A
Sludge Surge Tank			
Transfer Pump	One (1)		
Overboard Pump	One (1)		
Galley/Turbid Holding Tank			
Overboard Pump	Two (2)		

Discussion

The system installation does not appear to be acceptable.

The Chrysler Option A components, a minimum gray water holding tank (similar to System Nos. 1 and 2), the Sludge Surge Tank and the pumps can be fitted in the compartment. However, there is insufficient room for the incinerator installation.

Vessel: VIGOROUS (210')

WMS No. 4 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Holding Tank for Black Water/ Holding Tank for Gray Water

	Required
Sewage Influent Surge Tank	313 gal. (42 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sludge Holding Tank	452 gal. (60 cu. ft.)
Grumman Unit without Incinerator	One (1)
Influent Surge Tank Pump	One (1)
Influent Surge Tank Overboard Pump	Two (2)
Galley/Turbid Holding Tank Overboard Pump	Two (2)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system installation does not appear to be acceptable.

Due to the quantity and configuration of the equipment required and the piping involved, there appears to be insufficient space available for a functional arrangement and for maintenance and repair in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 5 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Holding Tank for Combined Black and Gray Waters

	Required
Influent Surge Tank	1235 gal. (165 cu. ft.)
Sludge Holding Tank	1742 gal. (233 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Influent Surge Tank Pump	Two (2)
Influent Surge Tank Overboard Pump	Two (2)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required especially due to the space required by the Grumman MSD's in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 6 Full Volume Flush Gravity Collection/Holding Tank for Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water

	Required
G/T Influent Surge Tank	922 gal. (123 cu. ft.)
Sewage Holding Tank	5,418 gal. (724 cu. ft.)
Sludge Holding Tank	1,290 gal. (172 cu. ft.)
Optional Combined Sewage/ Sludge Holding Tank	6,708 gal. (897 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Sewage Holding Tank Overboard Pump	Two (2)
Influent Surge Tank Pump	Two (2)
Influent Surge Tank Transfer Pump	One (1)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space available in the existing Sewage Treatment Space on the Third Deck for anything other than a partial capacity Sewage Holding Tank and its overboard/pierside pumps.

Vessel: VIGOROUS (210')

WMS No. 7 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Incinerator for Black Water/Holding Tank for Gray Water

	Required
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sewage Influent Surge Tank	313 gal. (42 cu. ft.)
Fuel Oil Day Tank	25 gal. (3.3 cu. ft.)
Grumman Units with Incinerator	One (1) with One (1) Thiokol
Influent Surge Tank Pump	One (1)
Influent Surge Tank Overboard Pump	Two (2)
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, especially due to the space required by the Grumman MSD in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 8 Full Volume Flush Gravity Collection/Grumman Flow Through System with Sludge Incinerator for Combined Black and Gray Waters

	Required
Influent Surge Tank	1,235 gal. (165 cu. ft.)
Fuel Oil Day Tank	25 gal. (3.3 cu. ft.)
Grumman Units with Incinerators	Two (2) with Two (2) Thiokol Incinerators
Influent Surge Tank Pump	Two (2)
Influent Surge Tank Overboard Pump	Two (2)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, especially due to the space required by the Grumman MSD's with their incinerators in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 9 JERED Reduced Volume Flush Vacuum Collection/Holding Tank for Concentrated Black Water/Holding Tank for Gray Water

	Required
Vacuum Collection Tank Ass'y	250 gal. (165 cu. ft.)
Sewage Holding Tank	1,540 gal. (206 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sanitary Holding Tank Overboard Pump	Two (2)
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system installation appears to be acceptable subject to certain limitations.

Re-use of existing piping arrangements would have to be considered. A fresh water sanitary flushing system would be required.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) Due to space limitations the Sewage Holding Tank would be restricted to 740 gallons (99 cu. ft.), approximately 5'-6" L x 3' W x 6' H, located in the aft end of the compartment, port side.

(b) The minimum gray water holding tank discussed in System No. 1 would be located at the forward end of the compartment, port side.

(c) The vacuum collection tank assembly would be located at the forward end of the compartment, starboard side.

(d) The various overboard/pierside discharge pumps would be located at the aft end of the compartment, starboard side.

System No. 9 (Cont'd)

Drainage would be as follows:

(a) Sewage from all spaces would be collected by vacuum in the vacuum collection tank assembly. The garbage grinder drains would require a special vacuum valve similar to a urinal discharge type valve to permit proper collection.

(b) Galley and Turbid drains would gravitate to the small gray water holding tank for discharge overboard in unrestricted water and to the Sewage Holding Tank or pierside when overboard discharge is not permitted.

Vessel: VIGOROUS (210')

WMS No. 10 JERED Reduced Volume Flush Vacuum Collection/Incinerator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Vacuum Collection Tank Assembly	250 gal. (165 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Fuel Oil Day Tank	61 gal. (8.2 cu. ft.)
Incinerator	One (1) Jered
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system installation appears to be acceptable subject to certain limitations.

Re-use of existing piping arrangements would have to be considered. A fresh water sanitary flushing system would be required.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) The vacuum collection tank assembly would be fitted at the aft end of the compartment, predominantly to port.

(b) The incinerator, blower and fuel oil day tank would be fitted to starboard of the vessel's centerline.

(c) The vessel does not have a stack, since the diesel engine exhausts run aft to the weather via the transom stern. This apparently will offer complications as to if and how the incinerator stack can be satisfactorily led to the weather. The vessel will have to be carefully checked in this regard. Fire fighting protection and space ventilation will also have to be checked for adequacy.

(d) A minimum gray water holding tank (approximate 2'-3" L x 1'-6" W x 6' H) would be fitted at the forward end, port side.

(e) The gray water holding tank pump would be located in the forward starboard corner.

Drainage would be as follows:

(a) Sewage from all spaces would be collected by vacuum in the vacuum collection tank assembly. The garbage grinder drains would require a special vacuum valve similar to a urinal discharge type valve to permit proper collection.

(b) Galley and Turbid drains would gravitate to the small gray water holding tank for discharge overboard and to pierside.

Vessel: VIGOROUS (210')

WMS No. 11 JERED Reduced Volume Flush Vacuum Collection/GATX Evaporator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Vacuum Collection Tank Assembly	250 gal. (165 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Evaporator (GATX)	Three (3)-60 gal.
Catalytic Oxidizer	Three (3)
Galley/Turbid Holding Tank Overboard Pump	Two (2)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, especially due to the space required to fit all the evaporators and their piping in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 12 JERED Reduced Volume Flush Vacuum Collection/Holding Tank for Concentrated Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water

	Required
G/T Influent Surge Tank	922 gal. (123 cu. ft.)
Sludge Holding	1,290 gal. (172 cu. ft.)
Vacuum Collection Tank Assembly	250 gal. (165 cu. ft.)
Sewage Holding Tank	1,540 gal. (206 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Influent Surge Tank Pump	Two (2)
Sewage Holding Tank Overboard Pump	Two (2)
Sludge Holding Tank Transfer Pump	One (1)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, especially due to the space required by the vacuum collection assembly plus the Grumman installations, all in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 13 JERED Reduced Volume Flush Vacuum Collection/Grumman Flow Through System for Gray Water/Incinerator for both Concentrated Black Water and Gray Water Sludge

	Required
Galley/Turbid Influent Surge Tank	922 gal. (123 cu. ft.)
Vacuum Collection Tank assembly	250 gal. (165 cu. ft.)
Fuel Oil Day Tank	112 gal. (15 cu. ft.)
Grumman Unit with Incinerators	Two (2) with Three (3) Thiokol Incinerators
Vacuum Collection Tank Transfer Pumps	Three (3)
Influent Surge Tank Pumps	Two (2)
G/T Holding Tank Overboard Pump	Two (2)

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, expecially due to the space required by the vacuum collection assembly plus the Grumman installations with multiple incinerators, all in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 14 GATX Reduced Volume Flush M/T Pump Collection/Holding Tank for Concentrated Black Water/Holding Tank for Gray Water

	Required
Sewage Holding Tank	1,742 gal. (233 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Sewage Holding Tank Overboard Pump	Two (2)
G/T Holding Tank Overboard Pump	Two (2)
Macerator/Transfer Pump	To be shipchecked

Discussion

The system installation appears to be acceptable subject to certain limitations.

A fresh water sanitary flushing system would be required.

The system is similar to System No. 1 except that sewage collection for this system is by macerator/transfer pumps instead of gravity.

The Sewage Holding Tank required capacity can apparently be met in a tank approximately 6' L x 8' W x 6' H.

The equipment arrangement would be as indicated for System No. 1.

Vessel: VIGOROUS (210')

WMS No. 15 GATX Reduced Volume Flush M/T Pump Collection/Incinerator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Incinerator Feed Tank	125 gal. (17 cu. ft.)
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Fuel Oil Day Tank	61 gal. (8.2 cu. ft.)
Incinerator	One (1) Jered
Incinerator Feed Pump	One (1)
Incinerator Feed Tank Overboard Pump	One (1)
G/T Holding Tank Overboard Pump	Two (2)
Macerator/Transfer Pump	To be shipchecded

Discussion

The system installation appears to be acceptable subject to certain limitations.

A fresh water sanitary flushing system would be required.

Equipment would be arranged in the existing Sewage Treatment Space on the Third Deck as follows:

(a) The incinerator feed tank (approximately 2' L x 2' W x 4'-6" H) would be located on the port side, aft.

(b) The incinerator, blower, feed pump and fuel oil day tank would be located on the starboard side.

As far as an incinerator stack is concerned, see System No. 10 for the problem of finding a suitable run to the weather.

Fire fighting protection and space ventilation will also have to be checked for adequacy.

(c) Due to lack of more space, the galley/turbid holding tank would be restricted to 538 gallons (72 cu. ft.), approximately 4' L x 3' W x 6' H. It would be located on the port side, forward.

(d) The pumps associated with the equipment would be located along the vessel's centerline.

Drainage would be as follows:

(a) All sewage would be collected by macerator/transfer pumps and discharged to the incinerator feed tank. Pumps would either feed it to the incinerator or discharge it overboard or pierside according to prevailing restrictions.

(b) Galley/turbid water would gravitate to the G/T holding tank from which it would be pumped either overboard or to pierside.

Vessel: VIGOROUS (210')

WMS No. 16 GATX Reduced Volume Flush M/T Pump Collection/GATX Evaporator for Concentrated Black Water/Holding Tank for Gray Water

	Required
Galley/Turbid Holding Tank	15,480 gal. (2069 cu. ft.)
Evaporator Feed Tank	125 gal. (16.7 cu. ft.)
Evaporator (GATX)	Three (3) - 60 gal.
Catalytic Oxidizer	Three (3)
Evaporator Feed Pump	Two (2)
Evaporator Feed Tank Overboard Pump	One (1)
G/T Holding Tank Overboard Pump	Two (2)
Macerator/Transfer Pump	To be Shipchecked

Discussion

The system installation appears to be acceptable subject to certain limitations.

Equipment could be located in the existing Sewage Treatment Space on the Third Deck. The installation will be a little on the tight side depending on how the final piping arrangement is installed, since a number of components would have to be fitted on this rather small space.

A fresh water sanitary flushing system would be required.

Equipment could be arranged as follows:

(a) The evaporator feed tank (approximately 2' L x 2' W x 4'-3" H) would be on the port side, aft.

(b) The evaporators and their vapor treatment equipment would be located one on the vessel's centerline forward and two on the starboard side.

(c) The minimum gray water holding tank discussed in System No. 1 would be located on the port side, just forward of the evaporator feed tank.

(d) The evaporator feed pumps and the various overboard discharge pumps would be arranged functionally near the equipment served.

Drainage would be as follows:

(a) All sewage would be collected by macerator/transfer pumps and discharged to the evaporator feed tank.

(b) Sewage would be pumped either to the evaporators or to overboard or pierside connections depending on prevailing restrictions.

(c) Sludge from the evaporators would be pumped overboard.

(d) Galley and turbid water would gravitate to the minimum gray water holding tank for discharge either overboard or to pierside connections, depending on restrictions.

Vessel: VIGOROUS (210')

WMS No. 17 GATX Reduced Volume Flush M/T Pump Collection/Holding Tank for Concentrated Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water

	Required
Sewage Holding Tank	1,742 gal. (233 cu. ft.)
Galley/Turbid Influent Surge Tank	922 gal. (123 cu. ft.)
Sludge Holding Tank	1,290 gal. (172 cu. ft.)
Grumman Unit without Incinerator	Two (2)
Sewage Holding Tank Overboard Pump	Two (2)
G/T Influent Surge Tank Pump	Two (2)
G/T Influent Surge Tank Transfer Pump	One (1)
Sludge Holding Tank Transfer Pump	Two (2)
Macerator/Transfer Pump	To be shipchecked

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, especially due to the space required by the Sewage Holding Tank and the Grumman MSD's in the existing Sewage Treatment Space on the Third Deck.

Vessel: VIGOROUS (210')

WMS No. 18 GATX Reduced Volume Flush M/T Pump Collection/Grumman Flow Through System for Gray Water/Incincerator for both Concentrated Black Water and Gray Water Sludge

	Required
Sewage Surge Tank	122 gal. (16 cu. ft.)
Galley/Turbid Surge Tank	922 gal. (123 cu. ft.)
Fuel Oil Day Tank	112 gal. (15 cu. ft.)
Grumman Unit with Incinerators	Two (2) with Three (3) Thiokol Incinerators
Sewage Surge Tank Transfer Pump	Three (3)
Sewage Surge Tank Overboard Pump	One (1)
G/T Surge Tank Pump	Two (2)
G/T Surge Tank Overboard Pump	One (1)
Macerator/Transfer Pump	To be shipchecked

Discussion

The system installation does not appear to be acceptable.

There is insufficient space to include all the equipment required, especially due to the sizes of the Grumman MSD's in the existing Sewage Treatment Space on the Third Deck.